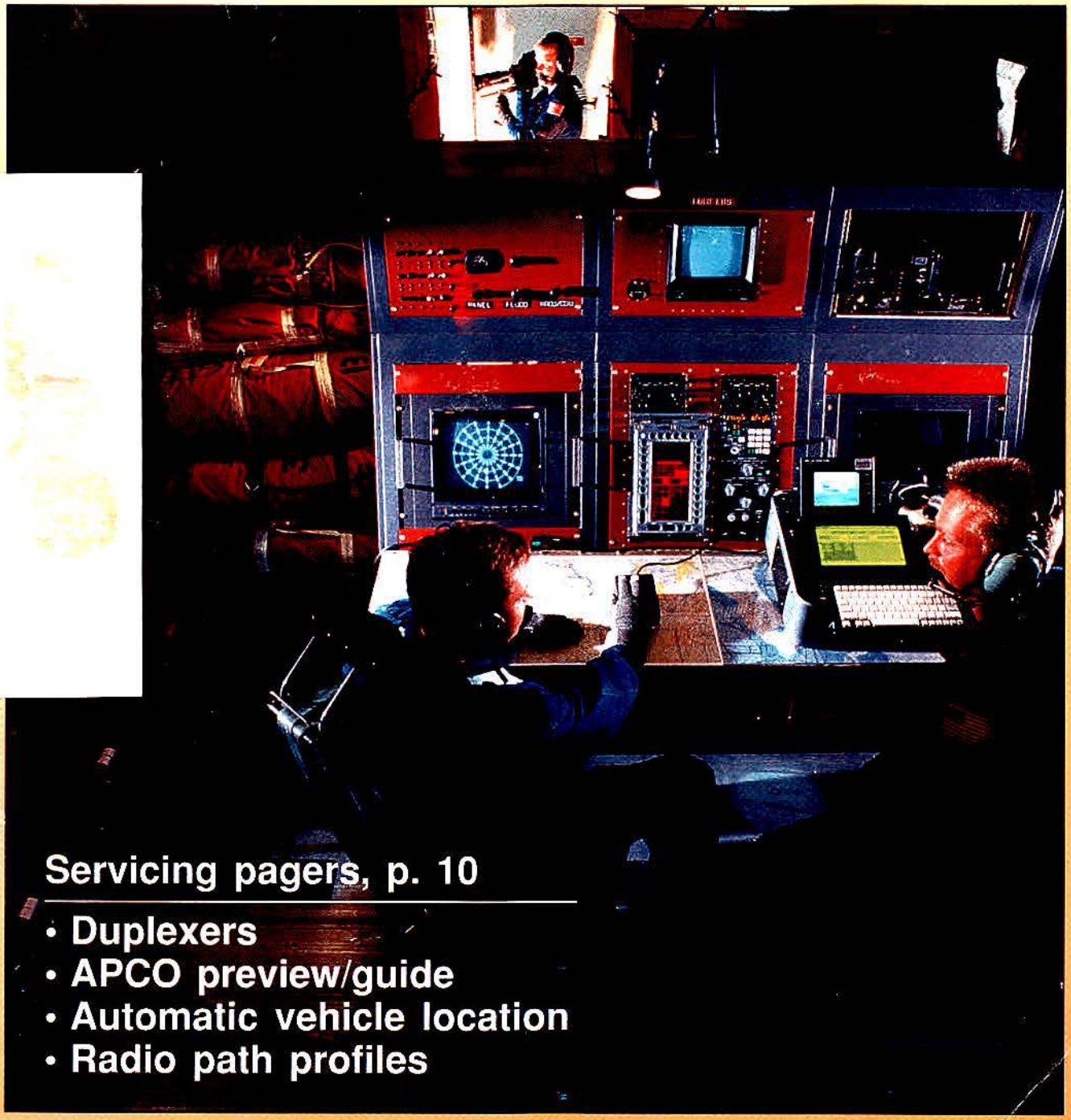
August 1994/$3

Mobile Radio Technology™

The journal of mobile communications technology



Servicing pagers, p. 10

- Duplexers
- APCO preview/guide
- Automatic vehicle location
- Radio path profiles

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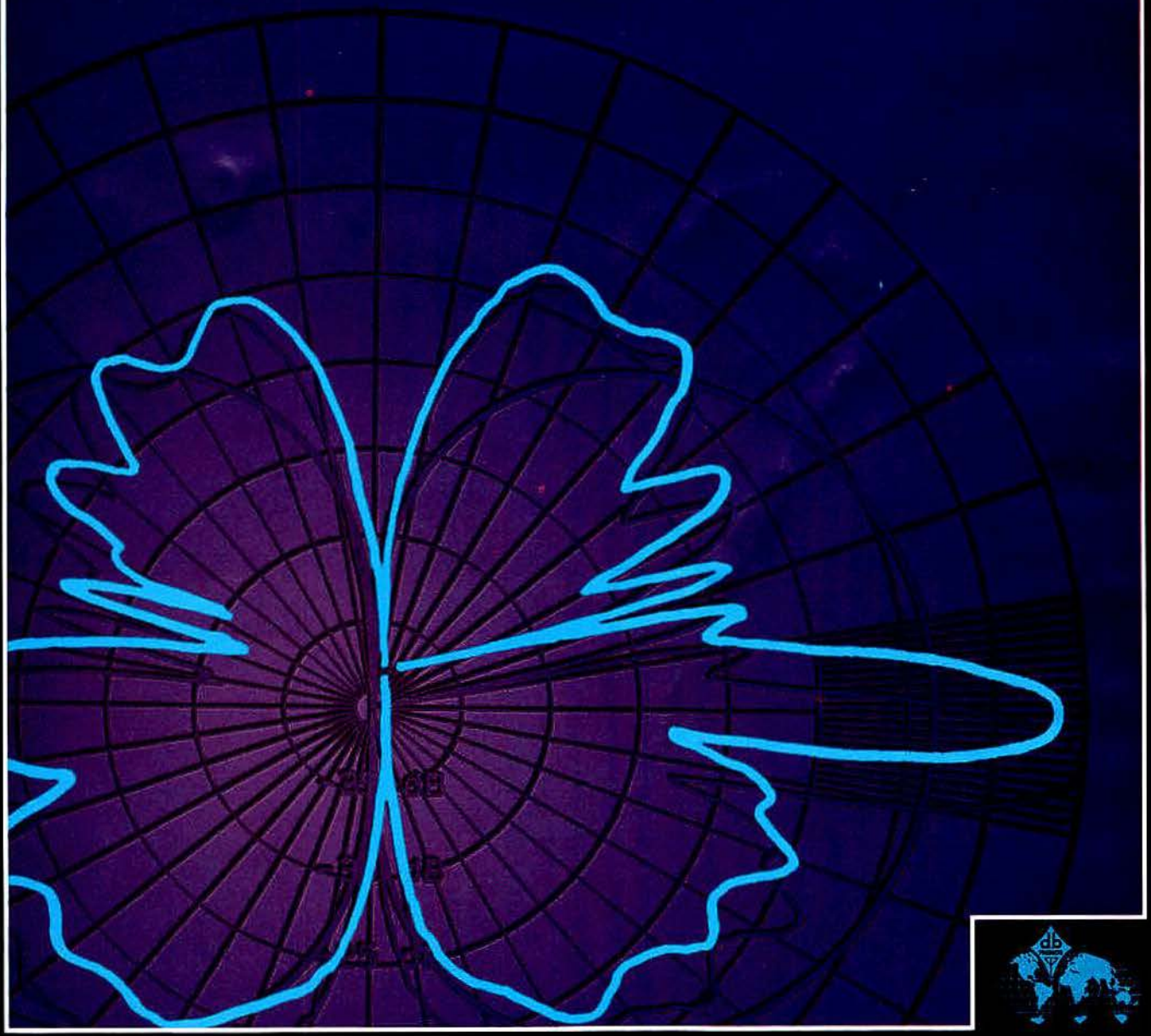

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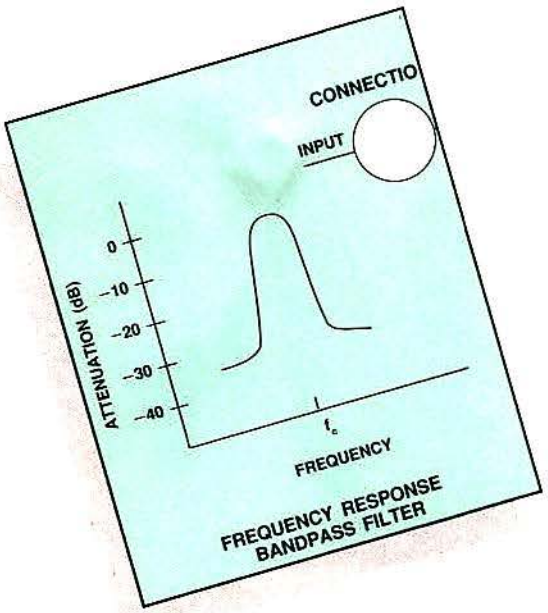

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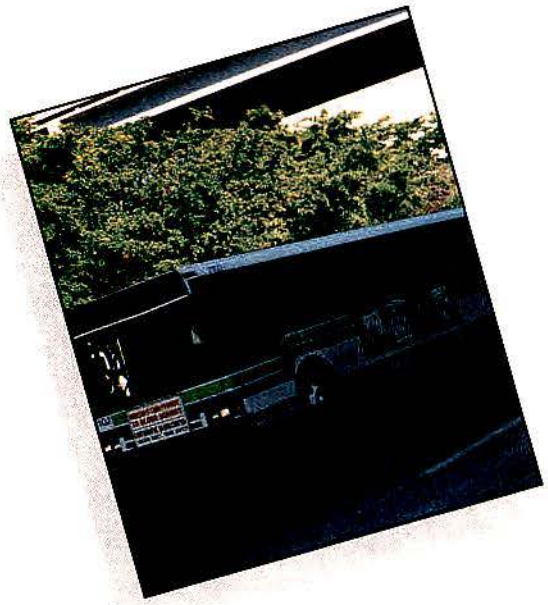

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features

On the cover: A digital imaging transmission system sends error-free, high-resolution photographs over narrowband radio links. The system is used in law enforcement, drug interdiction, surveillance and military operations. *Photo courtesy of Harris, Rochester, NY.*

departments

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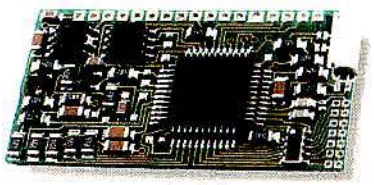

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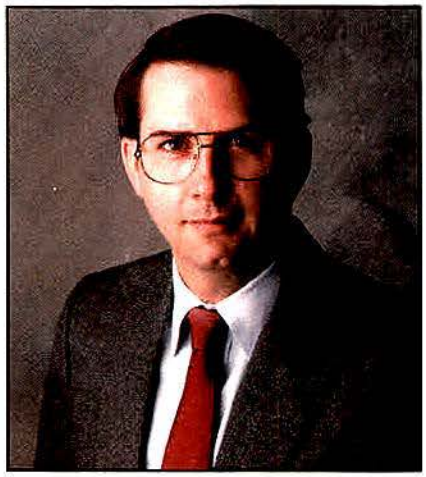

A piece of the PCS

Not yet a trade association, exactly, a "coalition of wireless telecommunications entrepreneurs" has been formed to advance their opportunities in becoming personal communications services (PCS) providers. The PCS Licensing Equity Alliance (PLEA) is supporting a bill in the U.S. House of Representatives titled "Communications Opportunity Act of 1994."

According to PLEA spokesman Lawrence R. Sidman, the act will direct the FCC to ensure that designated entities become license holders for spectrum-based services; ensure that the FCC reserves spectrum for designated entities under any licensing plan; lessen economic barriers to designated entities through tax certificates, bidding credits, lower fees and installment payments; and outline transfer of license and unjust enrichment rules applicable to designated entity license holders. A mouthful . . . but after all, it *is* legislation.

It sounds to us like a group of "have-nots" trying to use the power of the government to help them to become "haves," but that isn't *necessarily* bad. The FCC always loves it when interest groups persuade Congress to "direct" it to do one thing or another, so why should PCS interest groups hold back? The federal court probably will become involved after the fact, so maybe it makes sense to involve Congress before the fact. Let's not leave anybody out.

Research company reports about the revenue potential of PCS are one thing, but when this yet-to-be-born new communications service attracts the attention of telephone companies, cable TV system operators and various lobbyists, maybe it means there is *real money* to be made.

The PLEA can be reached through Lawrence Sidman at 901 15th St. NW, Suite 700, Washington, DC 20005; telephone 202-371-6206; facsimile 202-371-6279.

* * *

Wireless

We've poked fun at the word "wireless" from time to time, all the while recognizing that it has value as a "hot" word that draws attention to new communications products and services—and some that have been repackaged to look new. We've mentioned that radio first was called wireless, beginning nearly 100 years ago, and now the word has regained its former popularity. Still, the word "wireless" is a useful description that encompasses many forms of radio communications beyond mobile and portable two-way radios, especially as they may be perceived by customers. We're mindful of the possibility that the word may even find its way into our magazine title, as it has found its way into other magazine titles, trade association names and convention names.

Then along comes Art Wittman, the senior technology editor at *Network Computing* magazine. In the June 1 edition, he writes: "Wireless technology is in its infancy. The very name 'wireless' gives that away by describing the technology not for what it is, but for what it isn't. We don't call our cars 'horseless carriages,' and before long we won't be saying 'wireless networking' either." Say, how long *were* they called "horseless carriages," anyway?

* * *

. . . and more wireless

The Utilities Telecommunications Council has asked the FCC to create a Wireless Services Bureau that would include the functions of the present Private Radio Bureau and certain functions of the Common Carrier Bureau's Mobile Services Division (including PCS) and Domestic Radio Branch.

This kind of reorganization has a "hot" description of its own: "reinventing government."

Several other trade associations back the proposed consolidation of FCC regulatory power over mobile communications into a Wireless Services Bureau, including the American Mobile Telecommunications Association, the Personal Communications Industry Association and the Industrial Telecommunications Association.

It's a good idea, because it may help to prevent the interests of the remaining Private Mobile Radio Services from being trampled by the wireless herd when many former private services become common-carrier Commercial Mobile Radio Services.

—Don Bishop

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Make The RIGHT Connection

Circle (6) on Fast Fact Card

Calendar

August

6-11—International Municipal Signal Association, Cavenaugh's Inn, Spokane, WA. Contact: Harold Glerum, 800-723-4672.

7-12—Association of Public-Safety Communications Officials—International National Conference, Lawrence Convention Center, Pittsburgh. Contact: 800-949-2726.

September

22-24—Personal Communications Showcase, Washington State Convention Center, Seattle. Contact: 800-326-8638.

27-Oct. 1—International Conference on Universal Personal Communications, sponsored by the Institute of Electrical and Electronics Engineers, Hyatt Regency San Diego, San Diego. Contact: Nokia Mobile Phones, 800-306-6542.

October

3-5—WirelessWorld Conference & Exhibition, sponsored by *Cellular Business* magazine, The Stouffer Orlando Resort, Orlando, FL. Contact: Chris Lotesto, 800-458-0479.

19-21—International Wireless Communications Expo/Fall, Tampa Convention Center, Tampa, FL. Contact: 800-828-0420.

November

3-5—Industrial Telecommunications Association and **Council of Independent Communication Suppliers Annual Meetings,** The Kingsmill Resort and Conference Center, Williamsburg, VA. Contact: Barbara J. Levermann, 703-528-5115.

9-13—Communications Marketing Conference, sponsored by the Communications Marketing Association, Radison Plaza Lord Baltimore Hotel, Baltimore, MD. Contact: Jack Armstrong, 410-628-9300.

18—Radio Club of America, Communications Symposium, 85th Anniversary Dinner and Awards Presentation, New York Athletic Club, New York: Contact: Ron Formella, 201-652-6811.

December

6-8—Wireless Datacomm Fall, Washington Convention Center, Washington, DC. Contact: 800-322-9332.

1995

February

1-3—Cellular Telecommunications Industry Association Winter Meeting and Exposition, New Orleans. Contact: 202-785-0081.

March

TBA—Government Land Mobile Communications Conference, sponsored by TMSA Conferences, Washington, DC. Contact: Steven Silver, 310-534-4871.

13-14—AMTEX, the American Mobile Telecommunications Association's Marketing and Technology Conference and Exposition, The Buttes, Tempe, AZ. Contact: 202-331-7773.

20-23—Supercomm, sponsored by USTA and TIA, Anaheim Convention Center, Anaheim, CA. Contact: 202-326-7300.

April

3-5—Energy Telecommunications and Electrical Association, George R. Brown Convention Center, Houston. Contact: 214-235-0655.

25-27—International Wireless Communications Expo/Spring, Las Vegas Sands Convention Center, Las Vegas. Contact: 800-828-0420.

May

30-June 2—Radiocomm, Toronto Metropolitan Convention Center, Toronto. Contact: 613-233-4888.

July

26-28—Vehicular Technology Conference, sponsored by IEEE Vehicular Technology Society, Hyatt Regency Chicago O'Hare, Chicago. Contact: Keith Paglusch, chairman, 312-399-2378.

August

13-18—Association of Public-Safety Communications Officials—International National Conference, Detroit. Contact: 800-949-2726.

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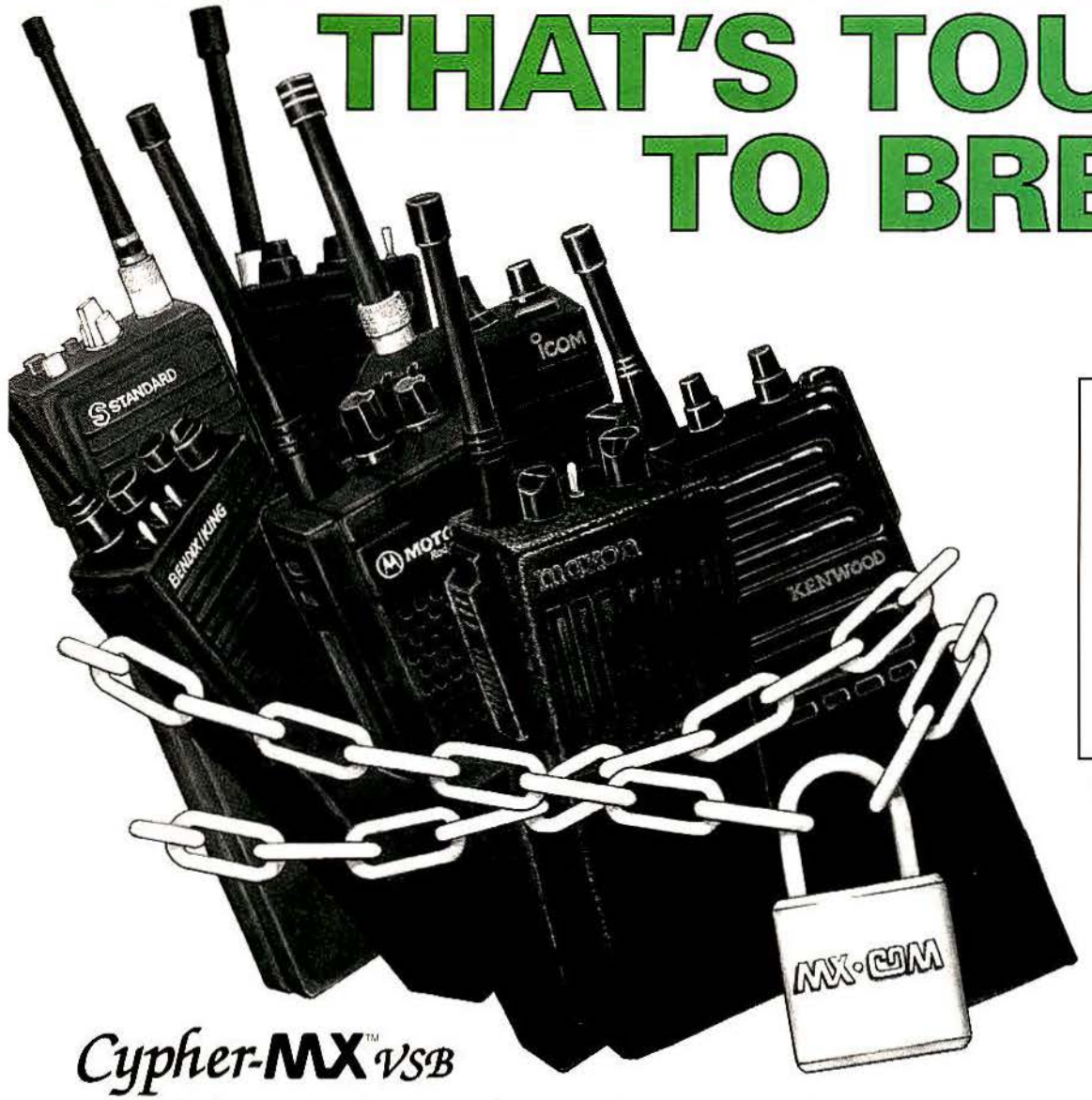

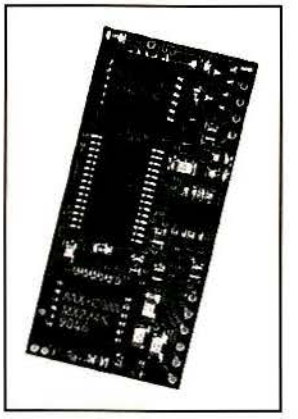

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Circle (7) on Fast Fact Card

Radio path profiles and the Fresnel zone

By Harold Kinley, C.E.T.

Establishing a highly reliable radio communications link between two fixed points often requires a line-of-sight path between the transmitter and receiver antenna, especially if the transmitter power is to be held to a minimum. For radio propagation purposes, the radius of the earth is considered to be 4/3 (1.333) times the natural radius. This longer radius produces a model of a "flatter" earth. (See Figure 1 to the right.) Thus, radio line-of-sight is approximately 15% greater than optical line-of-sight over smooth earth.

Formula 2 in the box on page 56 provides a means of calculating the maximum radio line-of-sight distance between two towers of given heights, h_1 and h_2. Suppose the height of the first tower is 100 feet, and the height of the second tower is 150 feet. The maximum allowable radio line-of-sight distance (D) between the two towers is:

$$D = \sqrt{2(100)} + \sqrt{2(150)}$$
$$= \sqrt{200} + \sqrt{300}$$
$$= 14.14 + 17.32$$
$$= 31.46 \text{ miles}$$

continued on page 56

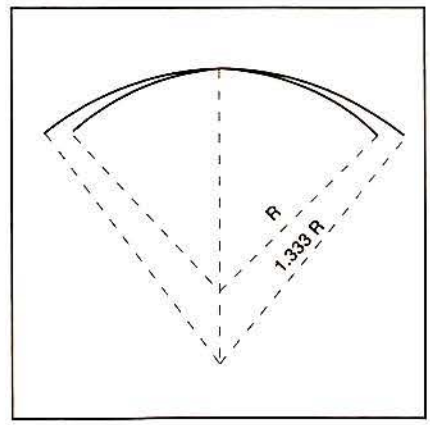

Figure 1. This graph shows how increasing the effective radius of the earth produces a 'flatter' earth, resulting in a longer line-of-sight distance between two points of given distance separation and antenna heights.

Kinley is a certified electronics technician with the South Carolina Forestry Commission, Spartanburg, SC. He is the author of *Standard Radio Communications Manual: With Instrumentation and Testing Techniques*, Prentice-Hall, 1985.

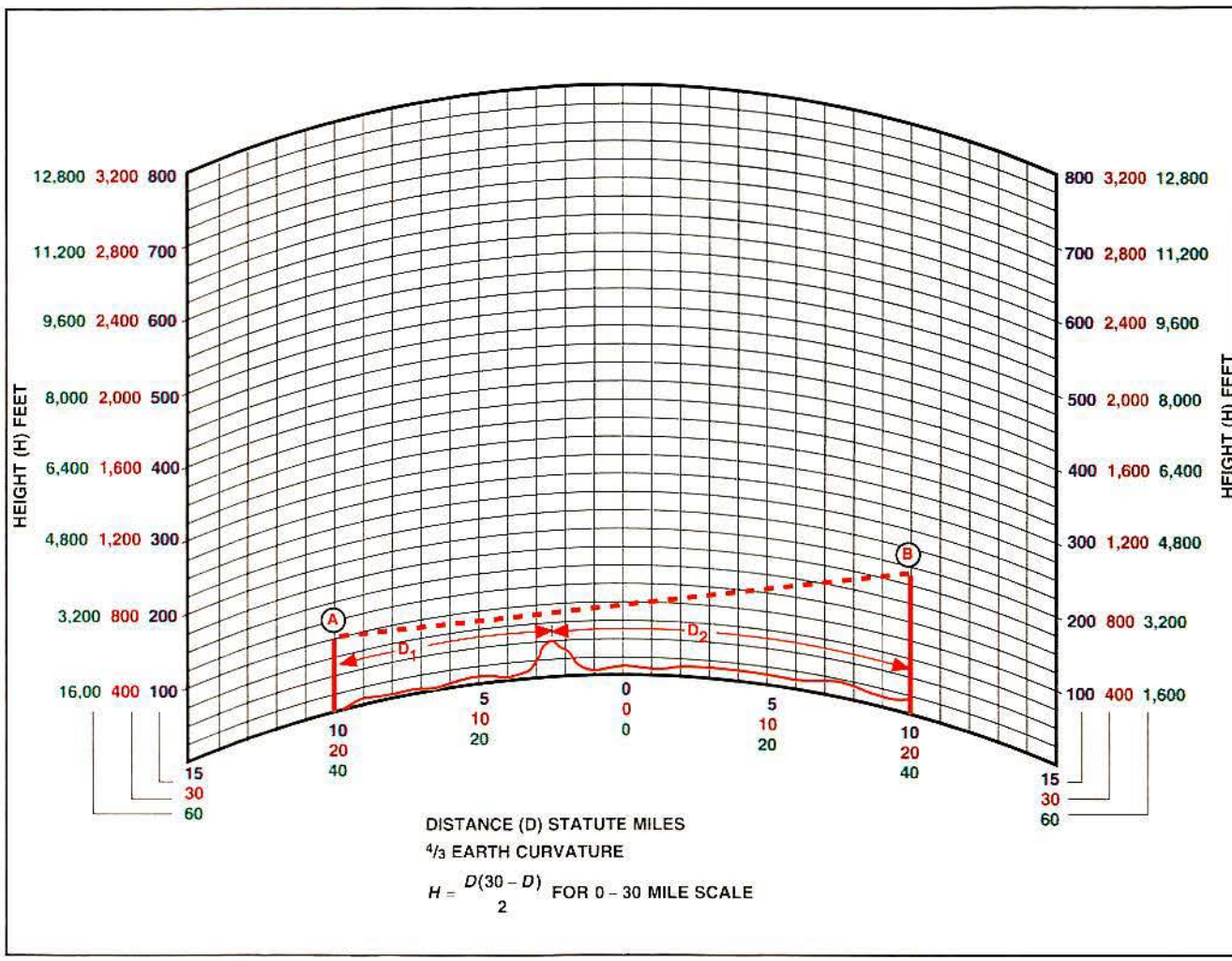

Figure 2. The 4/3 earth curvature profile paper is used to check for proper line-of-sight clearance between antenna towers A and B. Although a direct line-of-sight path exists, the large hill probably would prevent sufficient Fresnel zone clearance for free-space propagation loss. *Profile paper courtesy of Ericsson GE Mobile Communications.*

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Circle (8) on Fast Fact Card

Servicing pagers: 406MHz–512MHz receivers

Part 8—Here are some details about the inner workings of UHF Bravo receiver circuitry. Alignment information that makes use of some special equipment and techniques is included.

By David Ludvigson

As outlined in Part 5, the Bravo pager has been well-equipped to handle the 450MHz spectrum. Let's take a closer look at the NRE and AARE 406MHz–512MHz receivers.

The NRE series covers:

FREQUENCY BAND	MODEL NO.
406 – 420	NRE6421A,B
450 – 465	NRE6423A,B
465 – 480	NRE6424A,B
480 – 495	NRE6425A,B
495 – 512	NRE6426A,B

Figure 1 below is a block diagram of the NRE series receivers. (For additional detail, refer to the schematic diagram in the pager manual.)

An *outer loop antenna* is tuned by C402 and C403 to resonance at the operating

Ludvigson is a technician in Houston.

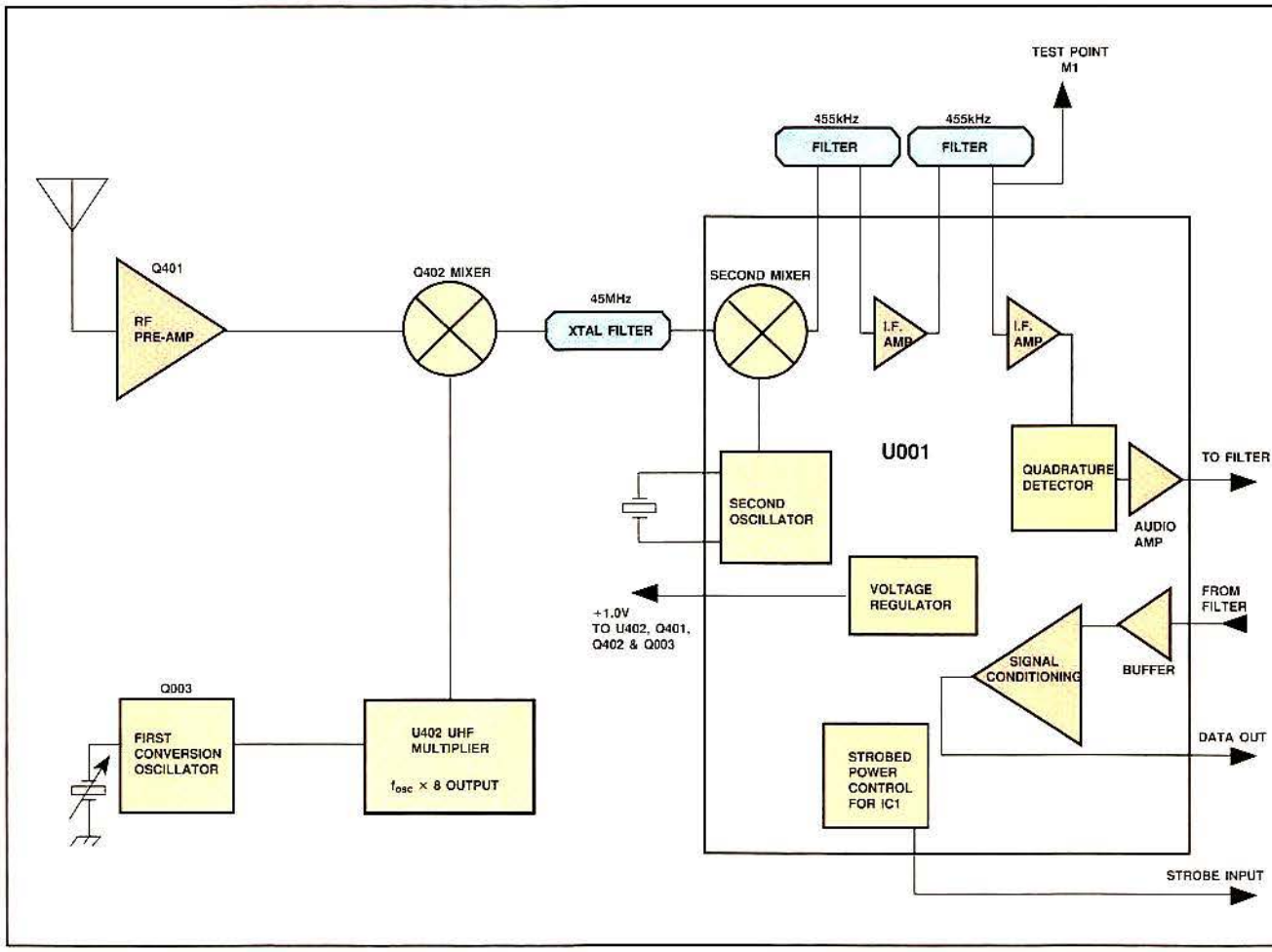

Figure 1. A block diagram of the NRE series 450MHz–512MHz receiver.

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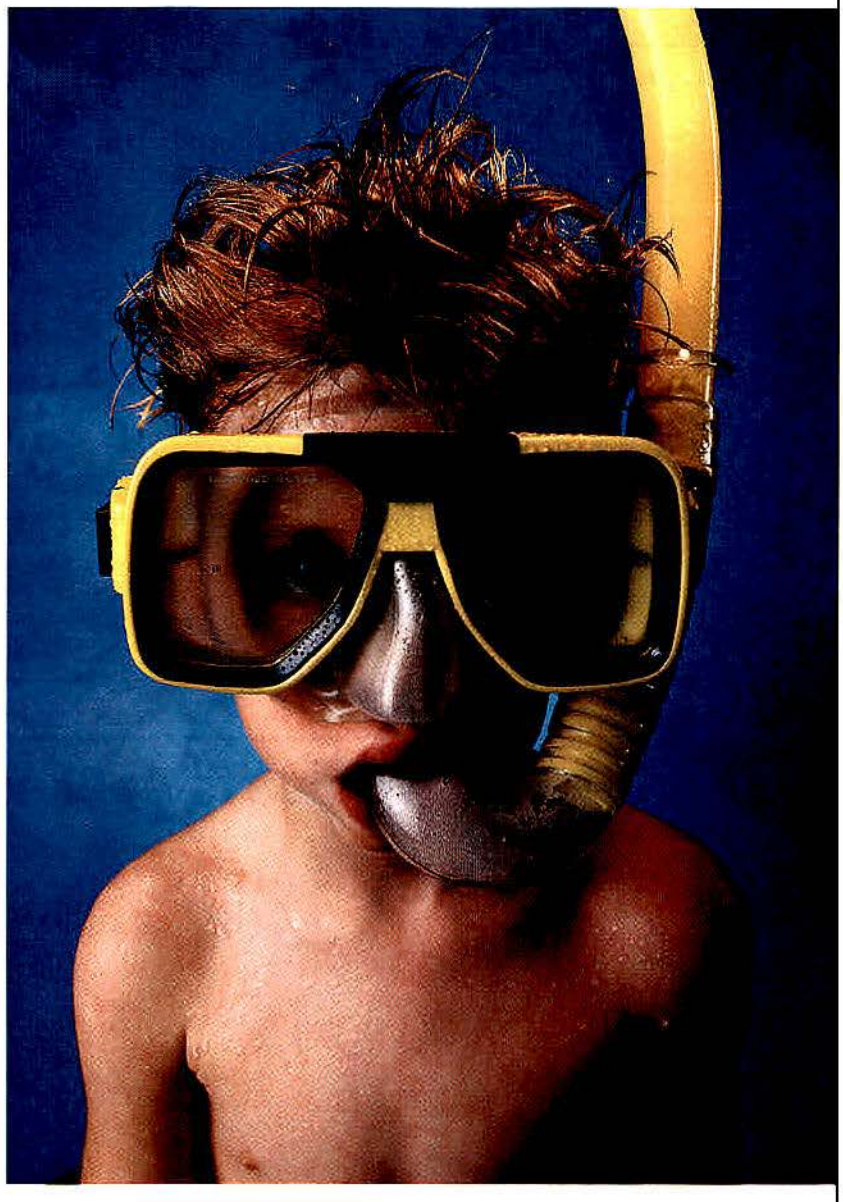

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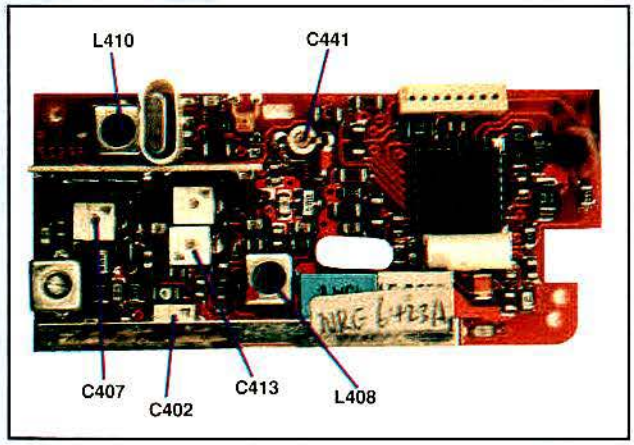
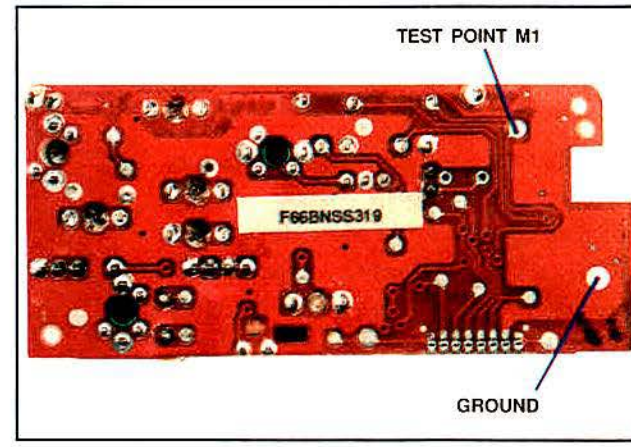
Circle (9) on Fast Fact Card

Alignment procedure: Bravo NRE series (45MHz IF)

The following procedure deviates somewhat from the suggested Motorola technique, and assumes the use of a shielded room (See Part 1) and the IFFER (See Part 2).

1. Set the signal generator to the exact frequency of receiver: F_{oper} = (8 × 1st conv. crystal) + 45MHz.
2. Frequency-modulate the signal with a 4.5kHz-deviated 1kHz tone.
3. Meter M1 using the IFFER and an oscilloscope.
4. Adjust L410 for close approximation of a sine wave (as viewed on scope). This should be the first peak as L410 is adjusted clockwise as viewed from the foil side of the circuit board.
5. Trim C441 to slightly distort the signal viewed in step 4. This adjustment affects the multiplier stage and causes "pulling" of the crystal oscillator.
6. Reduce the signal generator's output level. Adjust C441 (multiplier); L408 (45MHz filter response); C413 and C407 (antenna filter response); and C402 (antenna resonance)—in that order—to achieve maximum sensitivity.
7. Repeat step 6 as needed for maximum sensitivity. Output from signal generator should read −93dBm (5μV) for Golay or −90dBm (7μV) for POCSAG 1,200. Measurements are signal generator output level readings applied through a 6dB attenuator to the RTL-1005 fixture.





frequency. The *inner loop* transforms the incoming signal to a low impedance, matching the antenna to the RF pre-amplifier.

L403, R402, C404 and C405 provide negative feedback to Q401, stabilizing the common-emitter amplifier. Should the receiver be subjected to static discharges, CR001 will forward-bias with a negative voltage and clamp the discharge to ground.

Output from Q401 is coupled via C406 to C408, C407 and L405, which combine to form one portion of the bandpass filter. The rest of the filter consists of C412, C410, C413 and L406. This two-port filter provides attenuation of unwanted signals amplified by Q401.

Meanwhile, Q003 operates as a Colpitts oscillator at about 51MHz. U402 contains a parallel resonant circuit tuned to the 4th harmonic, across pins 2 and 3. The U402 module amplifies the resulting 204MHz signal, and then doubles it to produce an output at 408MHz (*Note:* Some versions use a tripler, followed by a doubler, for an overall ×6 multiplier stage.)

The resulting 408MHz signal from the first conversion oscillator is injected (along with the amplified antenna signal) at the base of Q402. The L409-and-C414 combination serves to bypass much of the 408MHz signal, while the antenna signal is virtually unaffected. Output from Q402, at 45MHz, may be adjusted by L408 to center the IF filter.

Once through the filter (FL401), the 45MHz signal mixes (at pin 12, U001) with the second oscillator signal at either

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DESCRIPTION	MODEL NUMBER WALL MOUNT	BASE TALK OUT FREQUENCY MHz
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900 MHz SMR FULL BAND	48522-N	935-941
BASIC CELLULAR A BAND	48549-N	869-891.5
ENHANCED CELLULAR A BAND	48550-N	869-891.5
BASIC CELLULAR B BAND	48543-N	880-894
ENHANCED CELLULAR B BAND	48551-N	880-894

45.455MHz or 44.545MHz to produce a 455kHz output at U01, pin 13. External filters at 455kHz are matched with on-chip amplifier stages before being detected by the active quadrature demodulator.

As mentioned in Part 6, the signal at test point MI is not FM! Until the received signal is demodulated, the input may be anything from AM to a dead carrier. There are *no limiters* in the Bravo receivers.

AARE series receivers

Figure 2 below is a block diagram of the AARE series receivers. (For additional detail, refer to the schematic diagram in the pager manual.)

These receivers are identified easily as having a triple set of tuning adjustments for the RF pre-amplifier stage, and as lacking the frequency multiplying module found in the other 406MHz–512MHz receivers (NRE series).

To begin with, a loop antenna network (E401, C451) is matched via C452 and C453 to the base of Q451. Diode CR451 performs as a static discharge device to prevent damage to Q451.

Q451 and Q452 are configured as *common emitter/common base* or *cascode*. The need for neutralization has been minimized by use of R453 across the resonant circuit L452, C455 and C456.

The helical filter (FL451) is adjusted to pass the RF signal at the antenna. AARE4001 receivers tune from 450MHz to 465MHz, and AARE4002 series receivers tune from 465MHz to 480MHz. As such, these helical filters tune the receiver accordingly.

As an example, in an AARE4001, the first conversion oscillator Q454 is in a Colpitts circuit operating at 51.12MHz. Output from Q454 is tuned to the 4th harmonic (204.48MHz) with tuned circuit L458 and C471. This signal drives multiplier Q455 (a frequency doubler) across L460 and C477 at 408.96MHz. L460 and C477 provide post-multiplier filtering at 408.96MHz.

Mixer Q453 combines the signals coming through the filter (FL451) and the signal from the oscillator-multiplier chain.

Pager servicing series

Part 1: "Build a Shielded Room," January 1994. (All pagers.)

Part 2: "Build An 'IFFER,'" February 1994. (Bravo, Bravo Plus, Bravo Express.)

Part 3: "Frequencies, Coding Formats," March 1994. (Bravo.)

Part 4: "From Bench To Programmer," April 1994. (Bravo.)

Part 5: "The Receivers," May 1994. (Bravo.)

Part 6: "Elegant Simplicity," June 1994. (Bravo.)

Part 7: "Problems In Paradise," July 1994. (Bravo.)

Part 8: "406MHz–512MHz Receivers," August 1994. (Bravo.)

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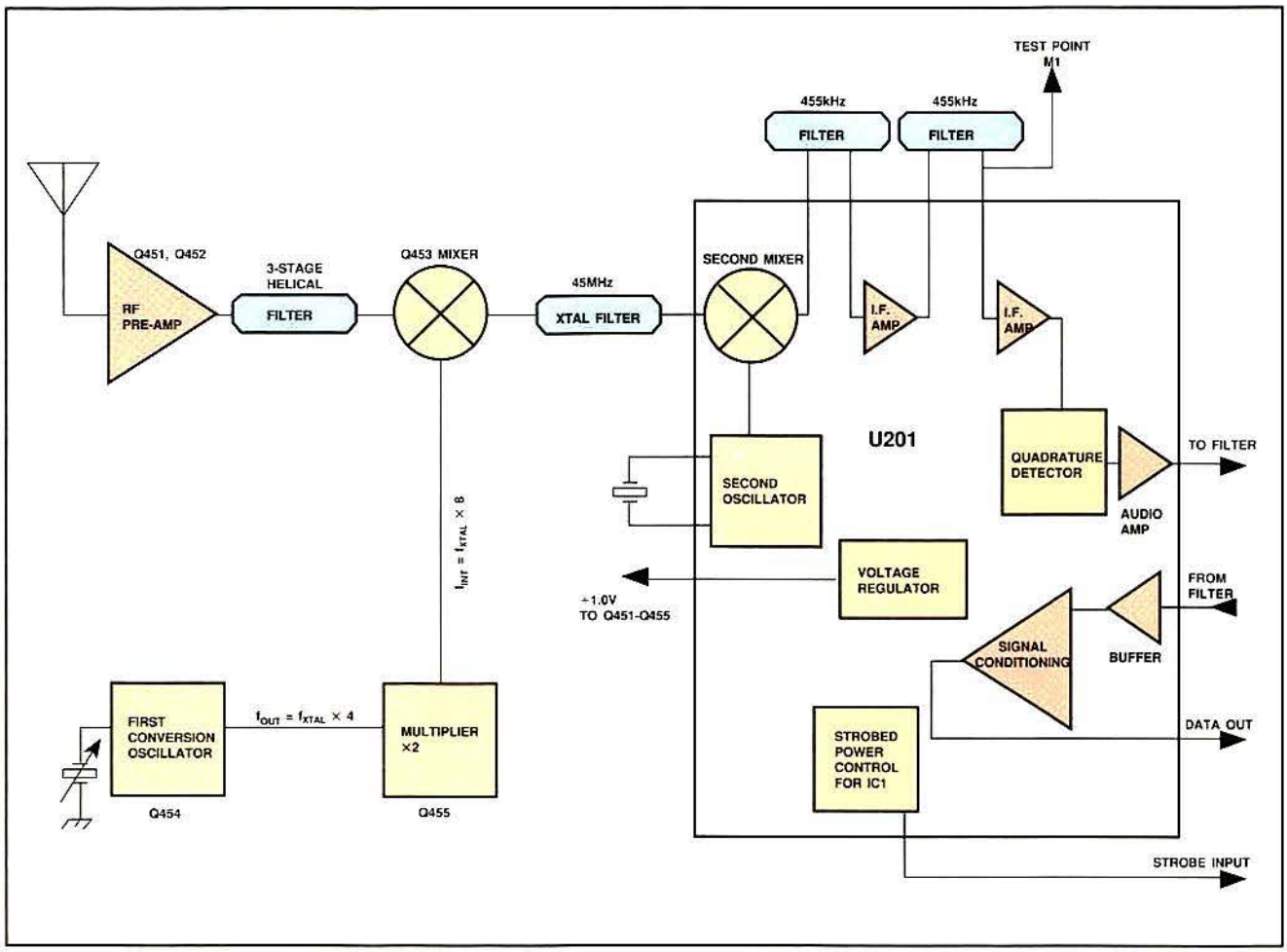
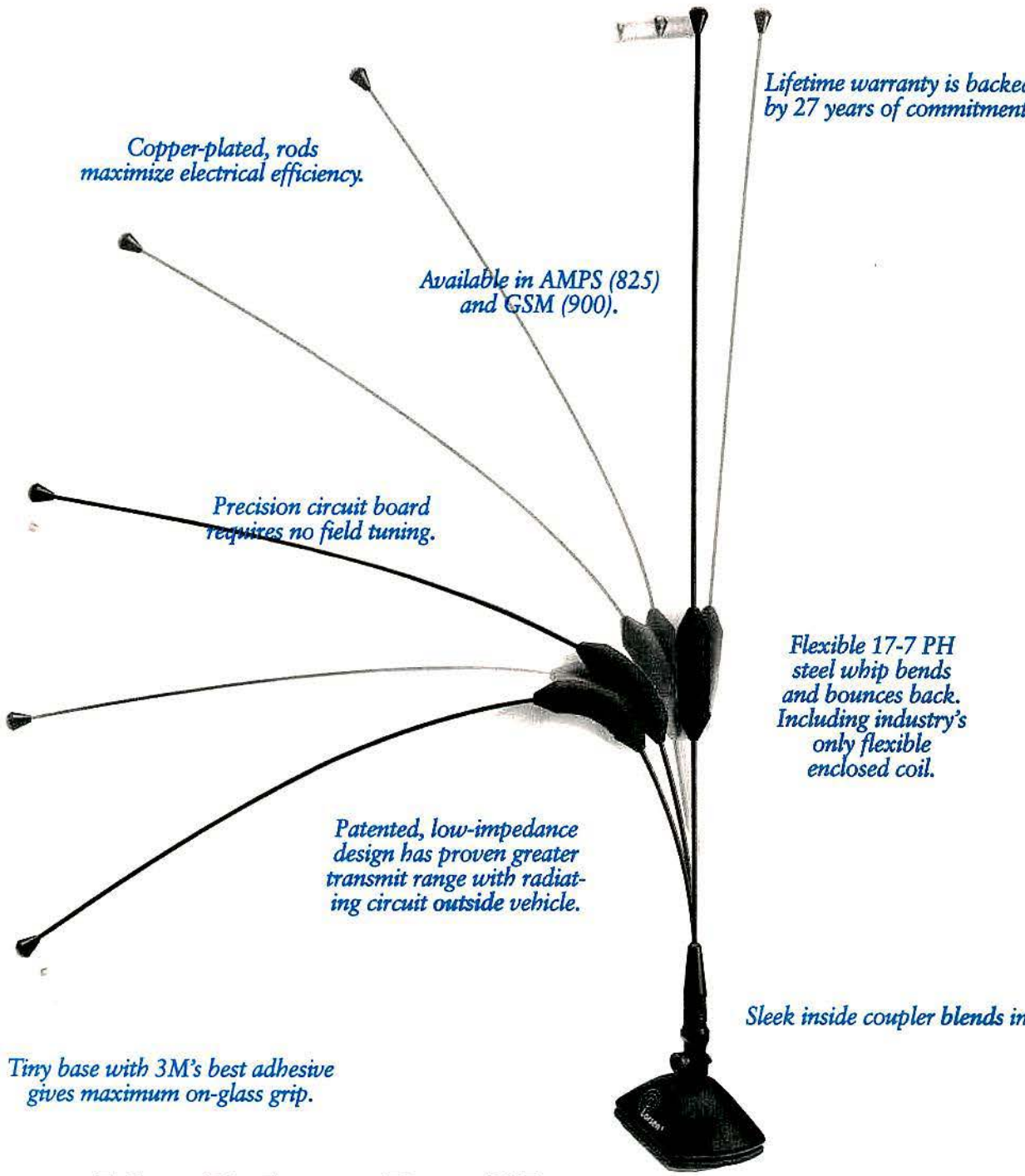


Figure 2. A block diagram of the AARE series 450MHz–480MHz receiver.



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Alignment procedure: Bravo AARE series (45MHz IF)

Note: FL451 has three sections. These will be noted as L1 (antenna side), L2 (intermediate section) and L3 (mixer side) in this procedure.

The following procedure deviates somewhat from the suggested Motorola technique and assumes the use of a shielded room (See Part 1) and the IFFER (See Part 2).

1. Set the signal generator to the exact frequency of the receiver (F_{oper} = (8 × 1st conv. crystal) + 45MHz.

2. Frequency-modulate the signal with a 4.5kHz-deviated 1kHz tone.

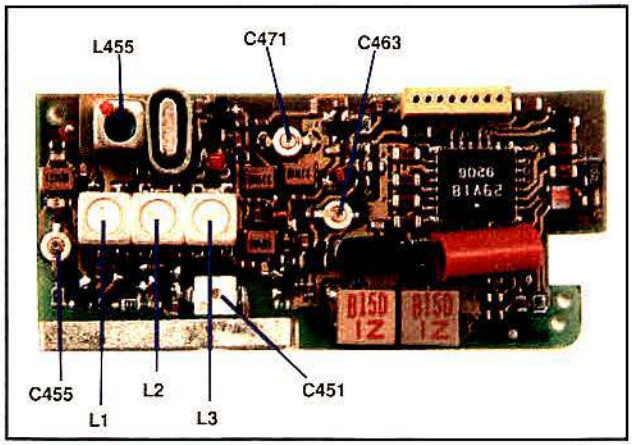
3. Meter M1 using the IFFER and an oscilloscope.

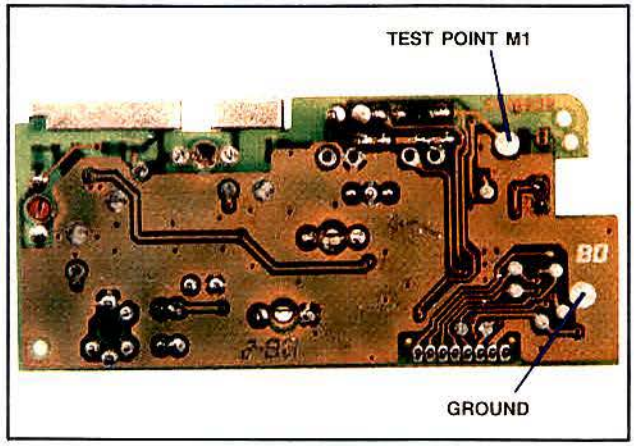
4. Adjust L455 for a close approximation of a sine wave (as viewed on scope). This should be the first peak as L455 is adjusted clockwise as viewed from the foil side of the circuit board.

5. Trim C471 to slightly distort the signal viewed in step 4. This adjustment affects the multiplier stage and causes "pulling" of the crystal oscillator.

6. Reduce the signal generator's output level. Adjust C471 (multiplier), C463 (45MHz filter response), L3 (mixer side), L2 (intermediate), L1 (antenna side), C455 (RF preamp output) and C451 (antenna)—in that order—to achieve maximum sensitivity.

7. Repeat step 6 as needed for maximum sensitivity. Output from the signal generator should read –93dBm (5μV) for Golay or –90dBm (7μV) for POCSAG 1,200. Measurements are signal generator output level readings applied through a 6dB attenuator to the RTL-1005 fixture.





The filter composed of C459, C460 and L453 effectively reduces the oscillator-side signal while allowing the antenna signal to pass. These values may be critical to mixer operation because antenna-side signal level and local oscillator injection levels determine both sensitivity and selectivity of the receiver.

The 45MHz output from Q453 is filtered by FL452, and then sent to the U001 "second mixer," along with the signal from the internal crystal oscillator (at either 45.435MHz or 44.545MHz). The resulting 455kHz signal then is filtered, amplified, filtered and amplified before it reaches the quadrature detector. Further processing of the signal delivers audio to TP8. External filters (on the decoder board) route back to the Data Fil I/P (TP10) where the retrieved audio is converted into a data stream and subsequently decoded.

Acknowledgement

I would like to thank J.H. Kim, owner of JJ Sounds, South Houston, TX, and co-workers Raymond, Tim and Pete, for their help with this project.

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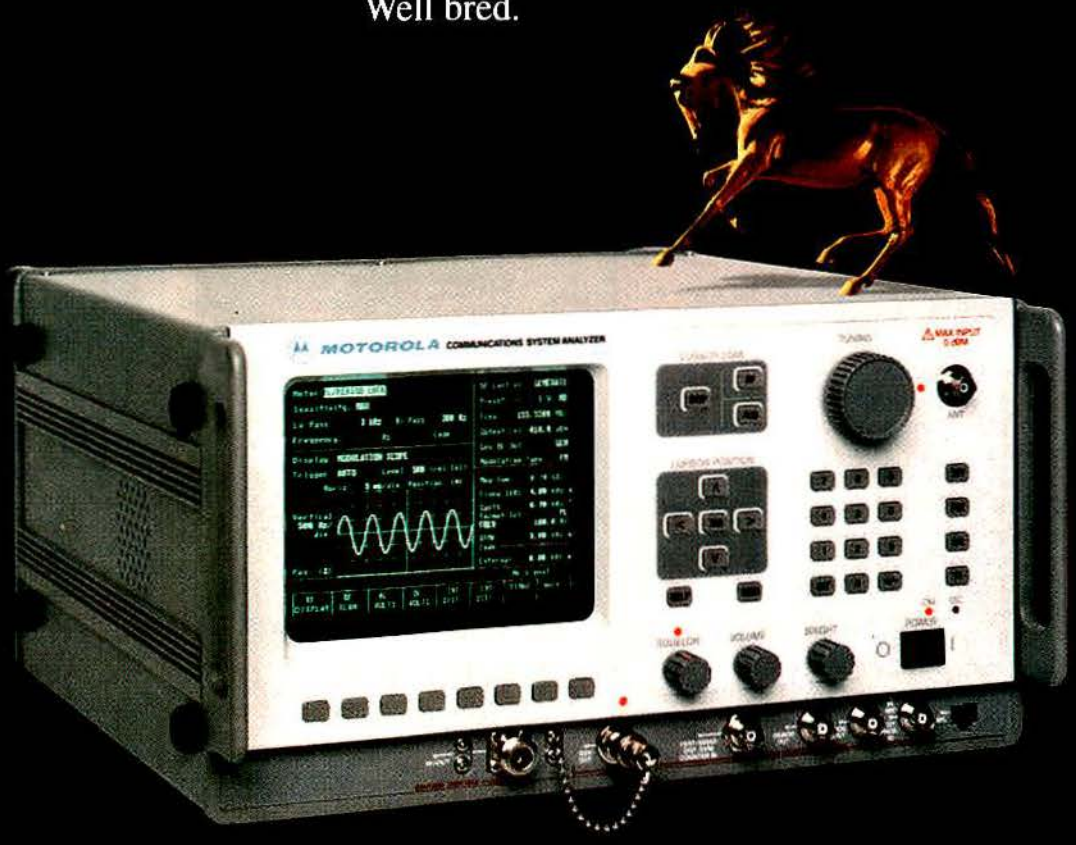

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How to use duplexers: The various types

Part 2—Applications for types of duplexers are described to help you choose and configure cavities for specific purposes. Frequency bands and frequency separation play a part in selecting the cavities.

By Brian J. Henderson, P. Eng.

Duplexers allow transmitters and receivers to operate simultaneously and to use the same antenna, as they do in typical repeater installations.

Various configurations can be used to filter interference, too.

The bandpass cavity

The bandpass cavity is the easiest type of duplexer to explain and to understand.

First, imagine a transmitter and receiver antenna separated by some distance. (See Figure 1A to the right.) The transmitter transmits energy that is radiated by the antenna and received by the receiver antenna and receiver. There is a loss between the two antennas.

If these two antennas were contained inside a cylinder, the losses between them would be reduced. Instead of the transmitting antenna radiating some energy in all directions, most of the energy would be contained inside the cylinder. Most of the energy would be picked up by the receiving antenna. Losses are reduced. (See Figure 1B).

The cylinder's length and volume affect the transmission path between the two antennas. This path between the two antennas is quite sharp and pronounced.

If the antennas are simple "loops" or short dipoles on opposite sides of a cylinder and the volume of the cylinder is adjusted by a conductive rod in the middle, the previously imaginary configuration has become a bandpass cavity filter. (See Figure 1C).

The bandpass cavity filter's frequency response is shown in Figure 2 top right.

Henderson is senior engineer, communications, with Canadian Western Natural Gas, Calgary, Alberta.

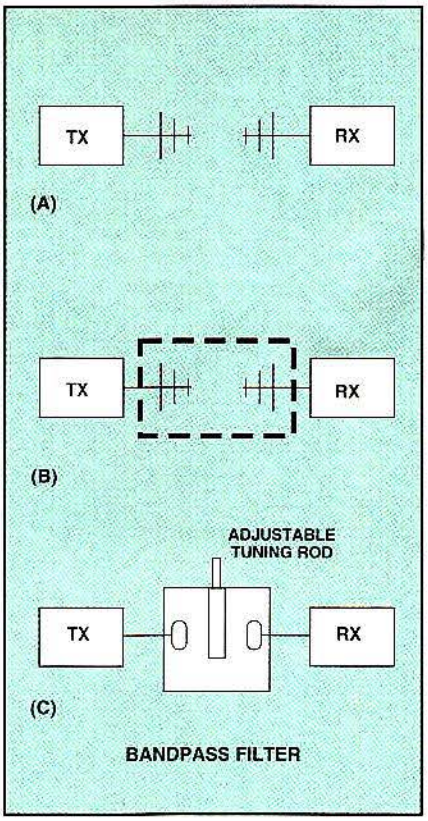

Figure 1. At (A), radio energy transferred between a transmitter antenna and receiver antenna is subject to a loss. If the antennas were within a cylinder, as in (B), the loss would be reduced. The cylinder's length and volume affect the transmission path between the two antennas. If the antennas are simple 'loops' or short dipoles on opposite sides of a cylinder, and the volume of the cylinder is adjusted by a conductive rod in the middle, the previously imaginary configuration has become a bandpass cavity filter, as in 1C.

The bandpass cavity can be adjusted for frequency by adjusting a "trombone slide" inside the cavity. Loss between the transmit and receive ports is at a minimum at the bandpass frequency and increases beyond the cavity's passband.

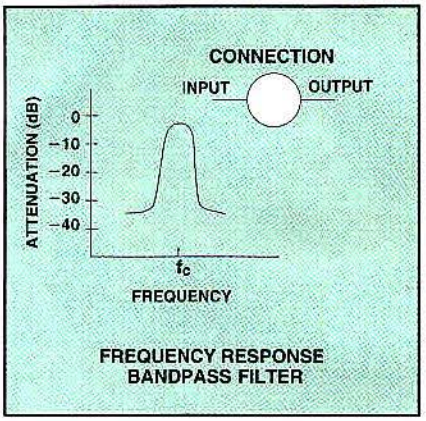

Figure 2. This is the frequency response of the bandpass cavity filter in Figure 1. The cavity can be adjusted for frequency by adjusting a "trombone slide" inside the cavity. Loss between the transmit and receive ports is at a minimum at the bandpass frequency and increases beyond the cavity's passband.

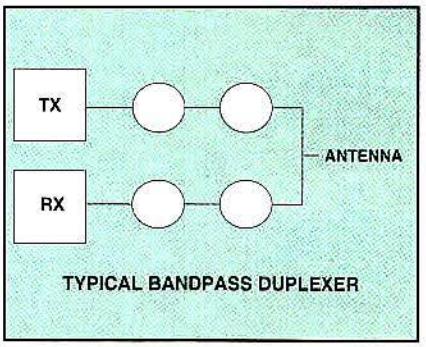

Figure 3. Several bandpass cavities can be combined to separate transmit and receive frequencies, as shown above. The idea is to provide enough isolation between a transmitter and receiver so that the same antenna can be used for both functions.

In addition, the SWR is at a minimum at the tuned frequency. SWR rises outside the bandpass cavity's passband.

Note that the physical diameter of the

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cavity has the effect of increasing the circuit "Q." The larger the diameter, the narrower the bandpass cavity and the higher the "Q." A 7-inch cavity is a better bandpass filter than a 5-inch cavity. A 10-inch cavity is better yet.

The bandpass duplexer

The function of a bandpass cavity has now been explained. So what does this do for the duplexer?

Several bandpass cavities can be combined to separate transmit and receive frequencies. The idea is to provide enough isolation between a transmitter and receiver so that the same antenna can be used for both functions. Such a duplexer is shown in Figure 3 on page 18.

Generally, two bandpass cavities are used in the transmit leg, and two are used in the receive leg of a repeater. Duplexers are connected in series with transmit and receive ports, as shown in Figure 3. The antenna port simply uses a "T" connector to parallel transmit and receive cables.

There is an advantage to using bandpass cavities to build a duplexer. The passbands of both the transmitter and receiver are narrowed.

In the case of the receiver, interference and intermodulation outside the passband of the receive cavities is reduced. Interference to other systems from your transmitter will be reduced.

There is one drawback to using bandpass cavities for a duplexer. Practical limits on construction constrain transmit-receive spacing to less than 2MHz at VHF and 5MHz at UHF frequencies. Bandpass filters do not provide enough isolation for closer transmit-receive frequency spacing.

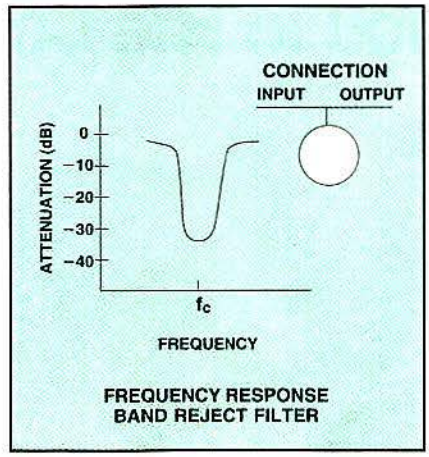

Figure 4. A reject cavity is a bandpass cavity with only one connector. The other connector either is left open or is omitted. The cavity's spectrum plot and connection diagram are shown above.

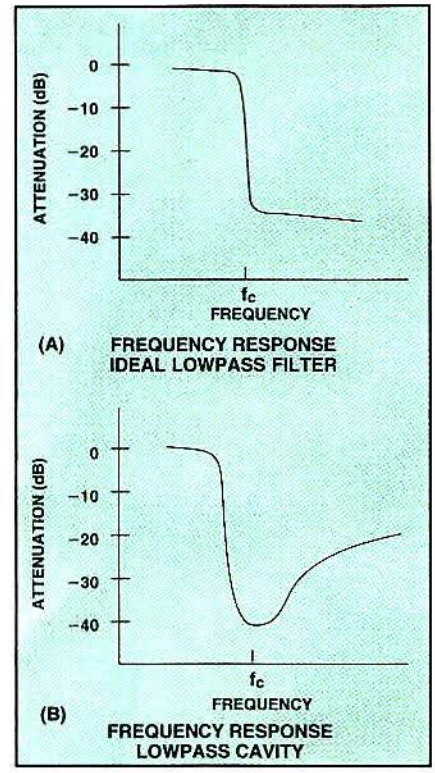

Figure 5. The graph at (A) shows the theoretical performance of a lowpass filter. It has a defined cutoff frequency. Below that frequency, signals pass with little loss. Above that frequency, signals are shorted out and do not pass through. A lowpass filter can be made by adding a capacitor in series with a bandpass cavity's feed loop. The pattern shown at (B) is that of a lowpass filter.

The reject cavity

Another common type of filter is called a reject cavity.

A reject cavity is simply a bandpass cavity with only one connector. The other connector either is left open or is omitted. See the spectrum plot and connection diagram shown in Figure 4 above left.

When connected into a transmission line with a "T" connector to "short out" a single frequency, the reject cavity removes the frequency from the line. This method commonly is used when another transmitter interferes with a receiver. A reject cavity is connected into the receive path to "notch out" the offending signal.

The lowpass filter

Another type of filter commonly used is the lowpass filter.

The theoretical performance of a lowpass filter is shown in Figure 5A above right. A lowpass filter has a defined cutoff frequency. Below that frequency, signals

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pass with little loss. Above that frequency, signals are shorted out and do not pass through.

A lowpass filter can be made by adding a capacitor in series with a bandpass cavity's feed loop. The pattern shown in Figure 5B is that of a lowpass filter.

The highpass filter

A highpass filter is the opposite of a lowpass filter.

Signals above the cutoff frequency pass through with little loss, and signals below the cutoff frequency are shorted out and do not pass through the highpass filter. (See Figure 6A to the right.)

The highpass filter also can be made by adding a capacitor in series with a reject cavity's feed loop. The pattern shown in Figure 6B is that of a highpass filter.

Note that the highpass and lowpass filters have exactly the same construction.

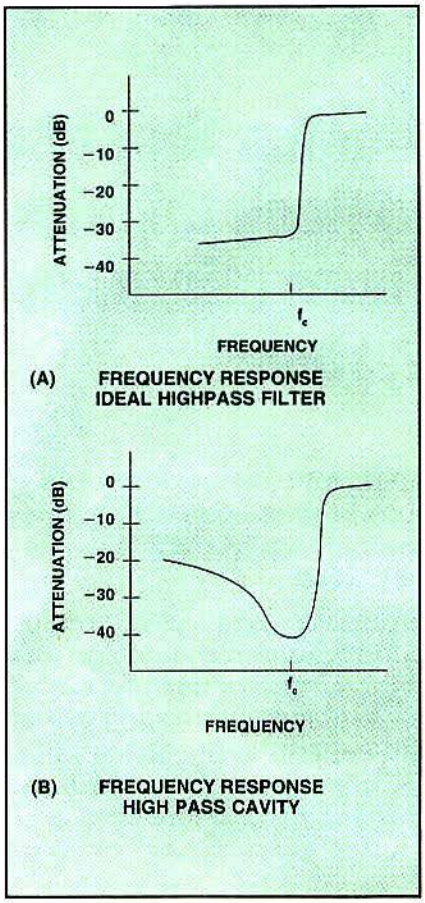

Figure 6. A highpass filter is the opposite of a lowpass filter. As shown at (A), signals above the cutoff frequency pass through with little loss, and signals below the cutoff frequency are shorted out and do not pass through the highpass filter. The highpass filter also can be made by adding a capacitor in series with a reject cavity's feed loop. The pattern shown at (B) is that of a highpass filter.

Near the feed connector on a filter you will see a small screw for adjusting the capacitor.

The capacitor setting determines whether the filter is a highpass or lowpass device, and it is not possible to tell from a visual inspection which type the cavity is. The only way to tell is by looking at the display of the cavity on a spectrum analyzer.

The bandpass/band-reject cavity

Highpass and lowpass filters could be combined together to form a duplexer.

There is a better way. A proper capacitor choice makes the filter a combination lowpass-highpass and bandpass filter, depending on the capacitor setting. (See Figures 5B and 6B.)

In this way, a single cavity connected to a receiver, for example, can pass the receive frequency with little loss and reject the transmit frequency. This forms the

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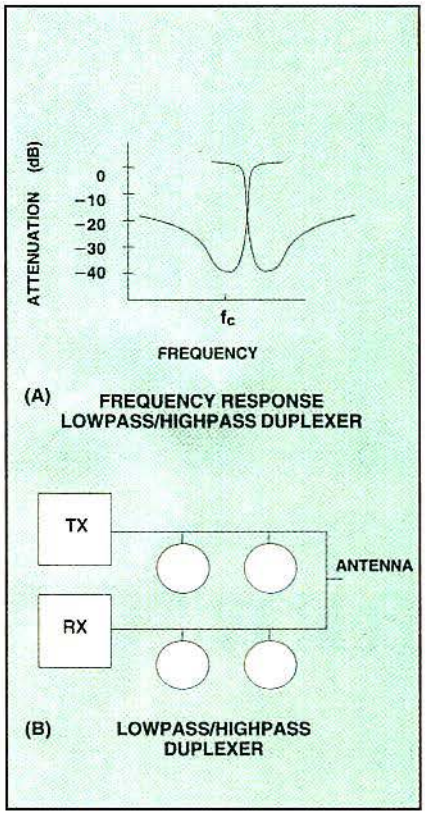

basis of the typical highpass-lowpass duplexer.

The bandpass/band-reject duplexer

Remember the isolation calculations performed earlier?

To get the 70dB–75dB of isolation required, two bandpass/band-reject cavities can be connected into each of the repeater's transmit and receive legs. (See Figure 7 to the left.)

Two cavities in the transmit side and two cavities in the receive side provide the required 70dB–75dB of isolation. In this case, minimum frequency separation is about 500kHz.

If a frequency spacing less than 500kHz is required, three cavities can be used on each side. This configuration increases isolation to about 90dB. The minimum frequency separation is about 300kHz at VHF. This separation is a practical limit of this type of duplexer. Adding more cavities increases the loss while providing little additional rejection.

Next: How duplexers are constructed and how they are installed have much to do with their tuning and frequency stability. Suggestions are included for ordering duplexers and for initial tuning or retuning.

Figure 7. Remember the isolation calculations described in the text? To get the 70dB–75dB of isolation required, two bandpass/band-reject cavities can be connected into each of the repeater's transmit and receive legs, as shown to the left. Two cavities in the transmit side and two cavities in the receive side provide the required 70dB–75dB of isolation. In this case, minimum frequency separation is about 500kHz.

Duplexer series

The previous installment in this article series is "How to use duplexers: Isolation requirements" in the July 1994 issue.

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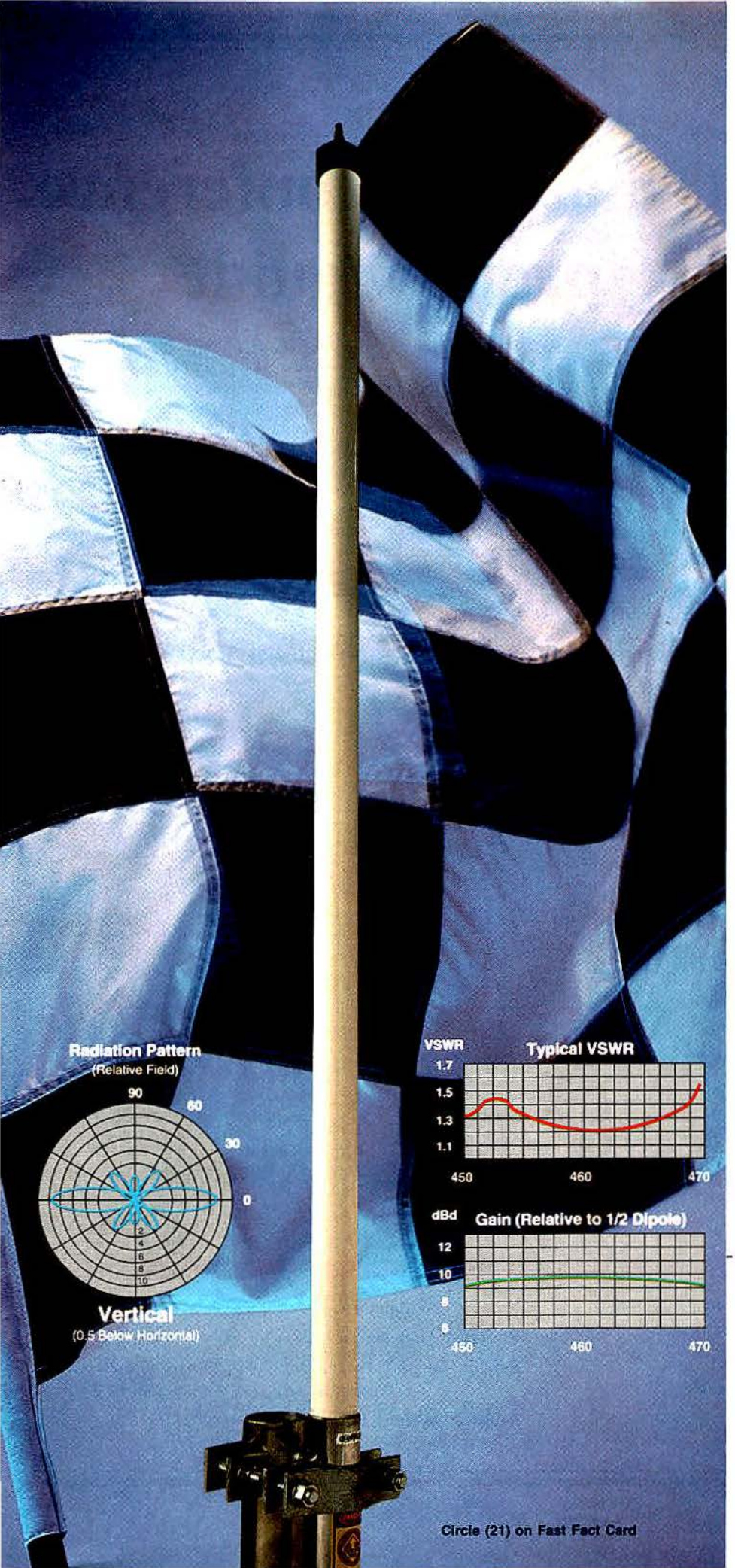

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APCO SHOW SECTION

APCO national conference '94 preview/guide

Welcome to *Mobile Radio Technology's* preshow coverage of the 60th annual national conference and exhibition of the Associated Public-Safety Communications Officials—International. This section is designed to help you plan your time at the Pittsburgh Convention Center, Pittsburgh, PA, August 7-11.

Sections inlcude:

- a map of the exhibit hall on page 28.
- a list of exhibitors and their booth numbers.
- a summary of exhibitors' products and services that will be on display. Exhibitors listed include those who submitted information as of press time.

More than 200 public safety communications manufacturers, distributors and service providers will convene at the Pittsburgh Convention Center. Products on display will include antennas, accessories, automatic vehicle location equipment, batteries, lightning protection equipment, mobile and portable radios, mounts, obstruction lighting, paging equipment, test equipment, towers and other wireless-related items. For a rundown on what exhibitors plan to showcase at this year's APCO show, refer to the products and services section beginning on page 34. The names of exhibitors who are also advertisers in this issue are highlighted in blue ink. Page numbers where you can find their respective advertising are also listed.

Refer to the list below of the concurrent seminar tracks and the topics that are to be presented at the show. The topics are listed in random order. A daily schedule will be available in the Conference pocket guide and from the APCO Conference Department.

Tentative list of concurrent tracks and topics to be presented at APCO

(Topics listed in random order.)

Management & Planning

- Introduction to Intelligent Highway Systems
- Corporation & Agency Management Tools
- Management, Planning & Control of an 800MHz Radio Communications Project
- Governmental Cooperation for the Most Effective Use of 821MHz Frequencies
- The World Trade Center
- Reallocation of the 2GHz Bands for Personal Communications
- The Essentials for Written Communications for Public Safety Officials
- Lease Purchasing
- Weigh in Motion
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Information Systems Data/CAD

- Graphical Applications for Two-way Radio Communications
- The Economic Impact of Project 25
- Update: Windows and Windows NT
- Mobile Data Wireless Communications Systems
- Get the Facts About Mobile Communications
- APCO 25: Radio Data for Public Safety
- Public Safety Role in the Integrated City
- Open Systems Update Rural Addressing
- Computer-aided Dispatch Support
- Graphical Information Systems
- Planning for a Mobile Data Communications System

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- Revitalizing Your Department's S.O.P.
- The Solutions to 3 Major 9-1-1 Problems
- Integration Issues for Mobile Computing
- Amateur Radio: An Important Resource in Emergencies
- Modern Training Techniques
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- Empowering the Call Taker
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- Digital Migration: Making it Simple
- Taking the Mystery out of Scrambling & Encryption
- Wind Power & Solar Power Systems for Remote Communications Sites
- Improving Radio System Performance

9-1-1

- From the Console to the Classroom
- Stone Age to Space Age—You Can Get There From Here
- Equal Access to Emergency Services
- Telecommunications for the Deaf
- Washington State E9-1-1 Project
- Project Good Morning
- NITESTAR: Distance Measuring
- Back to Basics: Suicidal Callers
- 9-1-1 & Wireless—The Life Cycle of Enhanced 9-1-1 Projects
- Responding to TDD Calls
- California Highway Patrol 9-1-1 Response

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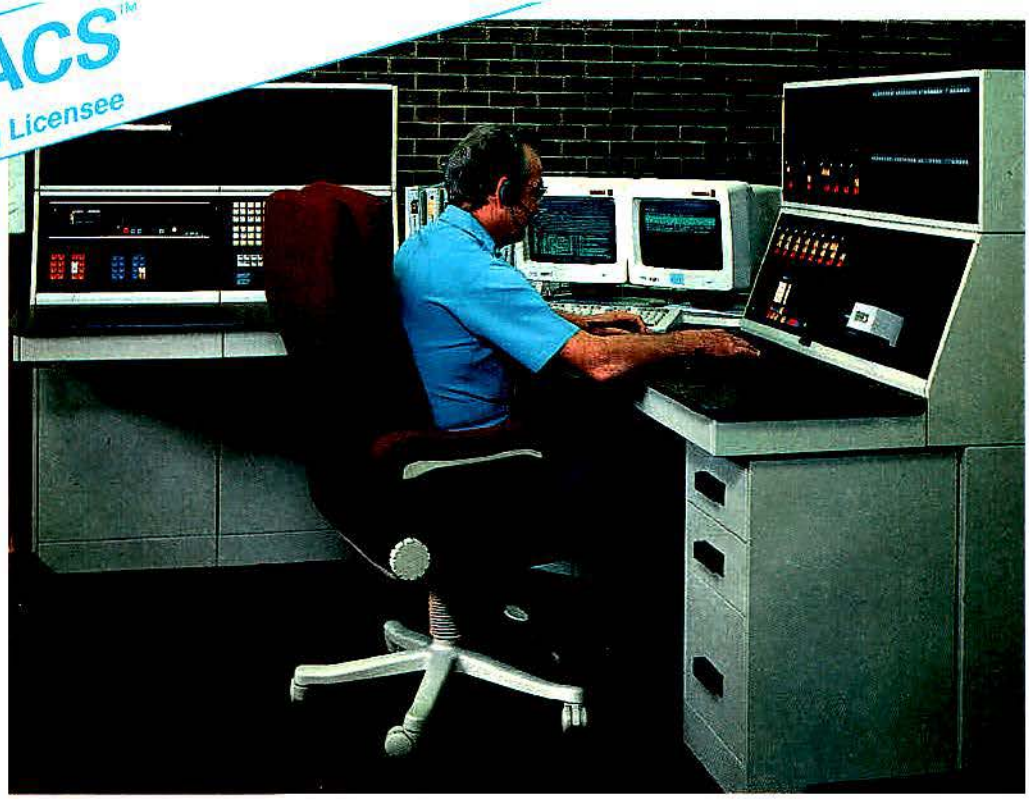


TDM-150: Our state-of-the-art, 120+ channel console

Count on the reliability and performance of communications consoles from Orbacom

In an emergency, reliable communications are the lifeline for survival. That's why so many communications systems rely on Orbacom's CALIDA and TDM-150 consoles. Their superior performance and solid dependability have been proven in the most demanding applications.

If you need the control flexibility of a big console on a small budget, CALIDA is for you. CALIDA handles 16 channels, includes a multi-format paging and signalling encoder, is completely user programmable, and features a 12/24 hour clock, VU meter, alert tone, crosspatch, service intercom, desk mic with PTT and monitor switches, surge protection, and a wealth of other professional features.

If your service requires a state-of-the-art dispatch console, Orbacom's TDM-150 is the solution. TDM-150 is a custom system, so we'll configure it the way you need it — up to 120 channels or more and 120 positions. TDM-150 uses time-division multiplex (TDM) digital audio processing and complete microprocessor control. Operation is simple and menu-driven. Reliability is ensured through surge protection, self-healing diagnostics, and battery backup. Eight levels of multi-channel radio and telephone patch may be run simultaneously, and an internal paging signalling encoder generates any sequence you'll ever need. Plus the best two-year console warranty in the business.

CALIDA: Big console flexibility for smaller systems

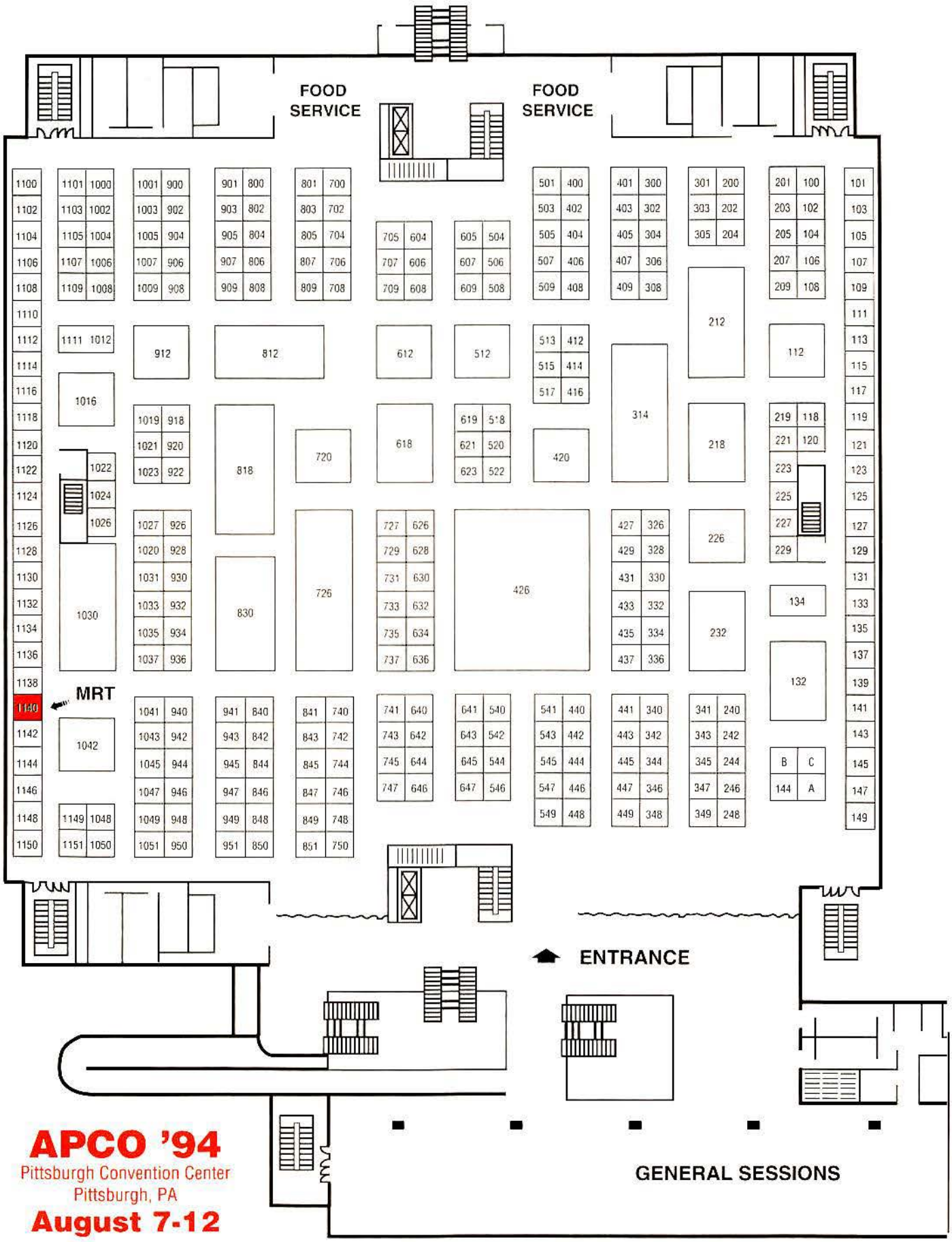
Mini-TDM-150 Desktop Console

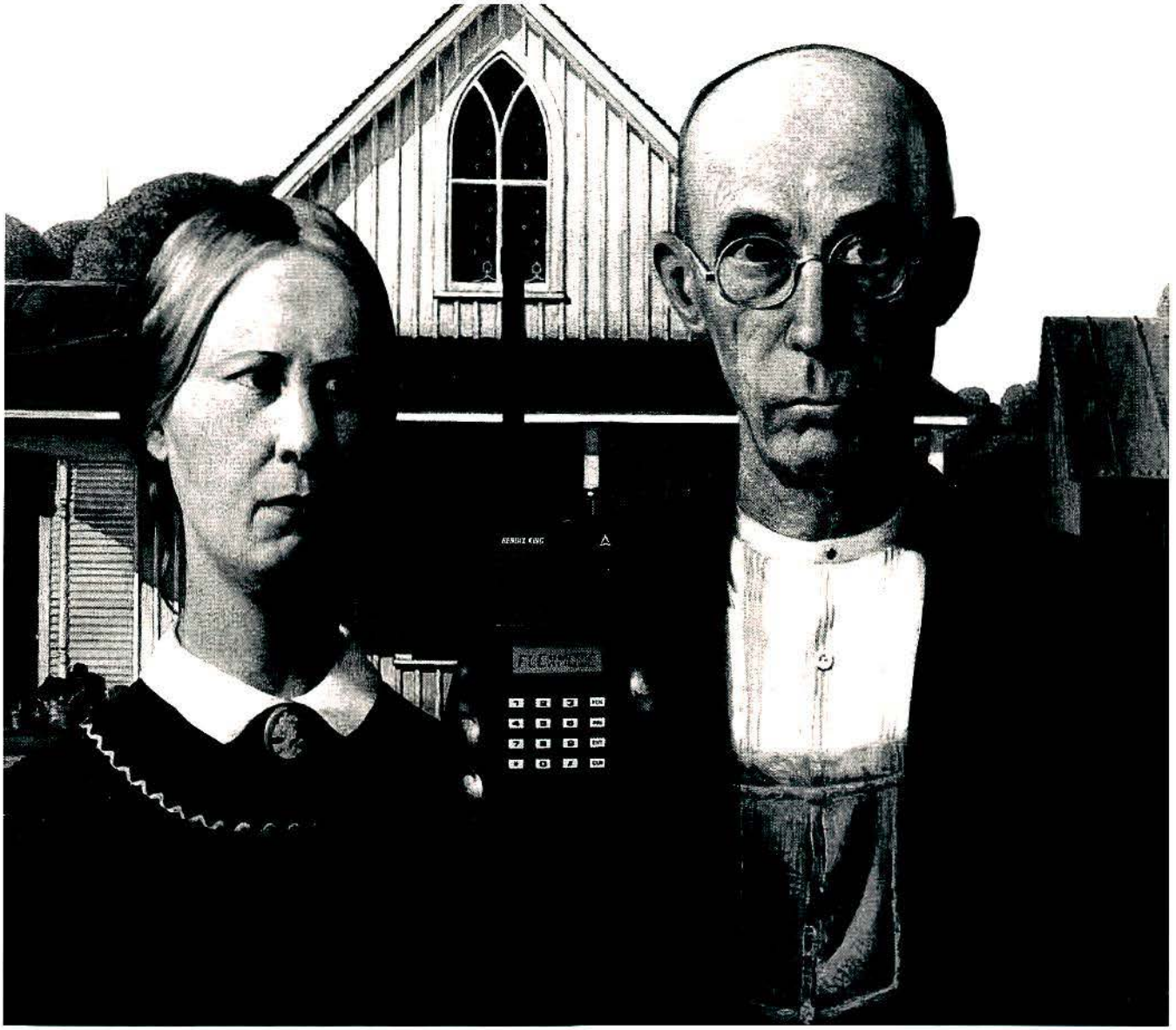
Take your pick. CALIDA for professional performance in smaller systems. And TDM-150 for state-of-the-art performance on 120 channels or more. Either way you can count on Orbacom. Our communications consoles are the most reliable you can buy, and have been since 1970.

Call (609) 829-4455 and let Orbacom solve your dispatching problems. Orbacom Systems, Inc., 1704 Taylors Lane, Cinnaminson, NJ 08077; FAX: (609) 829-6980.

ORBACOM SYSTEMS, INC.

Circle (22) on Fast Fact Card


FOOD SERVICE
FOOD SERVICE
MRT
ENTRANCE
GENERAL SESSIONS
APCO '94
Pittsburgh Convention Center
Pittsburgh, PA
August 7-12



"Lotta folks are worried about refarmin'. I just got a Bendix/King."

The FCC's efforts to increase spectrum efficiency, or "refarm" available frequencies, are well underway. No one knows what the future requirements will be, but Bendix/King's FLEX•MODE™ portable and mobile radios are programmable for today's needs as well as narrow band channel requirements.

FLEX•MODE™ innovation means a true 12.5-15/25-30 kHz channel spacing radio is here NOW. With Bendix/King, variable spacing is programmable on a per channel basis, so it's like two radios in one.
Need narrow band now? Need narrow band in the future? Call for FLEX•MODE™ today.

BENDIX/KING

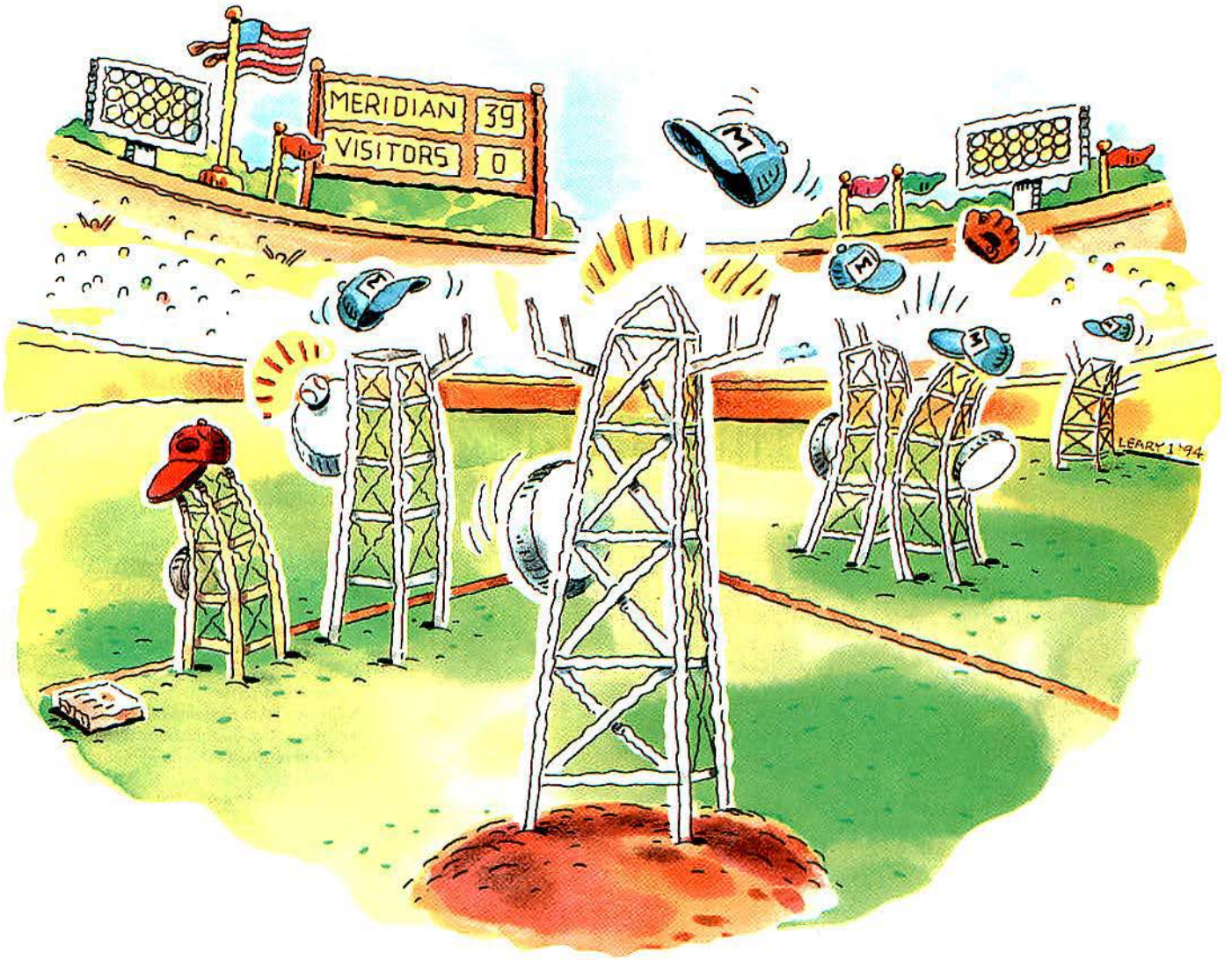
Be Prepared. Call Bendix/King:

1-800-648-0947

BK Radio, Inc.
a RELM Communications Company
2901 Lakeview Road, Suite 100
Lawrence, Kansas 66049
(913) 842-0402

Exhibitor List

9-1-1 Magazine (304)
911 Mapping Systems (1035)
Alcatel (643-647)
Allen Telecom Group (545-549)
Aluma Tower (101-105)
APCO Institute (809)
Argus Business (139)
AT&T (618)
Avtec (841, 843)
Badger Technology (207)
Ball Systems Engineering (845)
Banc One Leasing—
Municipal Leasing Div. (144A)
Bell Atlantic Mobile (727, 729)
BK Radio (226)
Cadex Electronics (747)
California Microwave—
TeleSciences Transm. (112)
Call One (341)
Carter Engineering (900)
Cast Products (1024, 1026)
CD Communications (141)
Cellular & Mobile International (1140)
Cellular Business (1140)
Celwave (544, 546)
Centurion International (1021, 1023)
Citadel Computer (513)
CML Technologies (442, 446)
Coded Communications (700, 702, 801, 803)
Combined Technologies (642)
Commercial Advisory
Committee (348, 1100-1106)
Communications Technology Assoc. (405)
Concepts-to-Operations (731)
Connect Systems (542)
CVDS (242, 244)
Cylink (408)
D.M. Data (137)
DataRadio (144, 144B)
Datumtech & Raymart (1016)
Delco/Hughes Automotive
Electr. Develop. (743, 745)
Dictaphone (420)
Digital Recorders (443, 445)
Dispatch Products (906, 908)
Domore Seating & Systems (930)
DX Radio Systems (149)
Dynamic Instruments (1006, 1008)
E.F. Johnson (326-336, 427-437)
ElectroCom Communications Systems (232)
Electronics Research—ERI (800)
Emergency Medical Services Magazine (200)
EmergiTech (706)
Ericsson GE Mobile
Communications (726-830)
Fibrebond (505)
Flash Technology (517)
Fleet Safety Equipment (1012)
Fluor Daniel (243, 245)
Fred A. Nudd (406)
Gamber Johnson (541, 543)
GE Capital Public Finance (942)
Geodynamics (1019)
Granger Telecom (1031)
!Habla! (1138)
Haddcomm International (741)
Harris (826, 826A-927, 927A)
Harris Farinon/Harris Lanier (818)
Heischman (248)
Hitech Systems (806, 808)
HTE Public Safety (807)
Hughey and Phillips (940)
IFR Systems (441)
Informer Computer Systems (918)
Inter-Commerical Business Systems (1110)
Intergraph (812)
Jems Communications (1033)
Kenwood USA (1048-1151)
Landmark Tower (1107, 1109)
Larimore Associates (1047)
Law Enforcement Product News (205)
LDV/Lynch Display Vans (1030)
Leach Mounce Architects/Schema Sys. (240)
LeBlanc Communications (946)
Logistic Mapping (306)
Logistic Systems (1049, 1051)
Magnasync/Comverse (847, 849)
MaSys (440)
Maxrad (340, 342)
Medical Priority Consultants (909)
Microwave Data Systems (118)
Microwave Radio (948)
Midland International (720)
Mobile Radio Technology (1140)
Mobile Telecommunications (1005)
Modular Communications (400, 402, 501, 503)
Motorola (426, 626-636)



We have major league experience.

Here's our pitch. When you're looking for antenna site space in Southern California, don't waste your time with minor leaguers. Meridian's team brings you over 38 years experience, plus a lineup of 39 sites with coverage that stretches from the Mexican border to Santa Maria. Our newest site is a rookie named Banning Peak which covers Banning Pass.

As Southern California's MVP, Meridian is a seasoned pro with state-of-the-art facilities. We're currently initiating continuous site monitoring to keep score of the temperature, electricity status and other variables. If something goes foul, we'll know!

And we're batting a thousand when it comes to stand-by power, air conditioning, and site maintenance. We also have a new high-security access system on deck for 1994.

Best of all, you'll get the personal touch of both our owner and our coach, Jack and Rich Reichler. Call us toll free at **(800) 400-SITE.**
And see why our fans think we're all stars. **Great sites, great service, since 1956.**

Meridian Communications

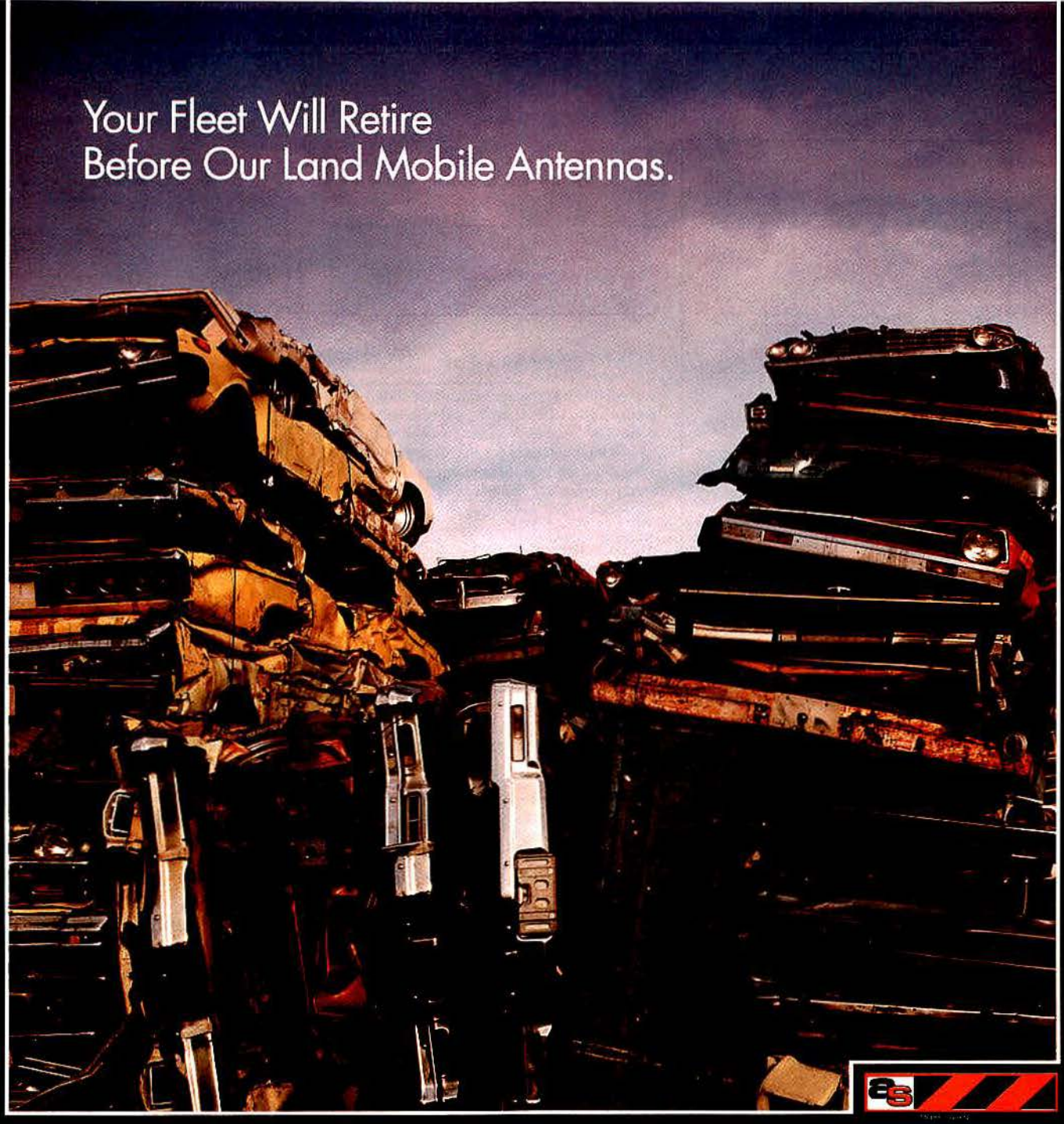
23501 Park Sorrento, Suite 213A, Calabasas, CA 91302-1355
(818) 888-7000 • (800) 400-SITE (7483) • Fax (818) 888-2857

Visit us at PCS in Seattle, Sept. 21-24, Booth #1010.

Circle (25) on Fast Fact Card

Motorola GSTG (344)
Myroka Sales (604)
National Emergency Number Assoc. (NENA) (1007)
National Safety Systems (1037)
Nationwide Tower (145)
New World Systems/ Public Safety Div. (932, 934)
Nexus Communications Business (1105)
Northpoint Communications Products (507)
Nu-Metrics (401)
OAR (246)
OCS Technologies (212)
Orbacom Systems (733-737)
Pacific Access Computers (203)
PacketCluster Systems (1043, 1045)
Pagetek (907)
Pandata/*Radio Resource* magazine (1003)
Plant Equipment (218)
PolyPhaser (644, 646)
Positron Industries (612)
PRC Public Sector (132)
Proctor & Associates (744, 746)
Promark (950)
Public Safety Equipment (143)
Public Safety Novelties (901)
Public Safety Product News (104)
Public Safety System (PSSI) (219-229)
Racal Recorders (748, 750)
RAM Communications Consultants (840, 842, 941)
RAM Mobile Data (848, 850, 949, 951)
RAM Systems Development (844, 846, 943, 947)
Relm Communications (1041)
Rescue 9-1-1 (404)
ROADsoft Solutions (903, 905)
Rohn Manufacturers (640)
Ropex (709)
Sabre Communications (147)
Scala Electronic (349)
SCC (Systems Concept of Colorado) (314)
Schlumberger Technologies (201)
Scientific Dimensions (134)
SE Technology (202, 204)
Sel-Tronics (912)
Setcom (623)
Skaggs Telecommunications Services (504-508, 605-609)
SKC Communication Products (801)
Slattery Software (805)
SMC Electro-Mount (300, 302)
Sonic Communications (347)
Southern Vehicle Products (1000)
Spectracom (305)
Spillman Data Systems (1009)
Spilsbury Communications (705)
SPJ Furniture Technology (608)
Stancil (540)
Stanilite Electronics (100, 102)
Steelgard (707)
Sti-Co (447, 449)
Stratus Computer (509)
Swager Communications (209)
TEAC America (414, 416)
Telex Communications (606)
Teltone (936)
Tessco (412)
The Institute for Disabilities Research & Training (1022)
Tiburon (518-522)
Time Communications (804)
Times Microwave (1002, 1004)
TPL Communications (149)
Transcrypt International (619, 621)
Trimble Navigation (920, 922)
TRW Systems Integration Group (926, 928, 1027, 1029)
TWR Lighting (708)
Tx Rx Systems (512)
U.S. CommStruct (944)
U.S. Department of Energy (OSP) (704)
UCS (308)
Ultratec (1001)
Unisys (1042)
UTC Service (515)
Valmont Industries (641)
Vega—A Mark IV Group (448)
Waldmann Lighting (108)
Warning Systems (346)
Watson Furniture Systems (407, 409)
Westinghouse Electronic Systems (902, 904)
Whelen Engineering (301, 303)
WirelessWorld magazine (1140)
Zetron (740, 742)

Your Fleet Will Retire Before Our Land Mobile Antennas.



As the industry's undisputed durability leaders, land mobile antennas from A/S Mobile never lie down on the job. Their superior technology, materials and manufacturing keep them working year after year. So you can retire your worries about land mobile antenna failure.

A/S Mobile designs antennas for virtually all land mobile applications. And we work overtime packing in features other manufacturers leave out. Features like rubber O-ring seals for moisture protection. 100% factory-tuned and locked coils for long-term frequency stability. And stainless steel whips for topmost durability. You can even ask for a flexible shock-absorbent spring for high-vibration environments. And all A/S Mobile antennas are designed for peak efficiency. So they work every shift at maximum performance.

Call A/S Mobile at 1-800-664-5274 and place your order for the highest quality antennas manufactured today. Unlike your retired fleet, the only thing our land mobile antennas will pile up is air time.

ALLEN TELECOM GROUP
A/S MOBILE

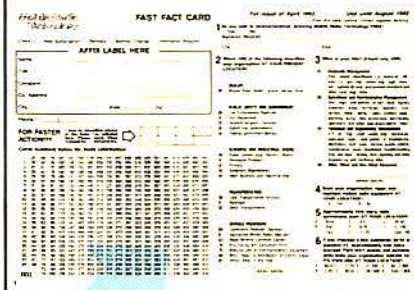
30500 Bruce Industrial Parkway
Cleveland, Ohio 44139-3996
216-349-8400
FAX 216-349-8407

Your Wireless Connection.™

Circle (27) on Fast Fact Card

Products and services

For more information on the products and services listed, fill out and return the Fast Fact Card on page 113. See sample below.



XYZ Communications **Booth 9999**
Existing services
Galaxywide paging, satellite rental, multilingual billing formats.
New products
Coin-size pagers. This unit operates on ambient heat and needs no batteries.
Circle 900 **See ad page 650**

Information listed was accurate at press time and is subject to change.

Allen Telecom Group Booths 545, 547, 549
Existing products
A/S Mobile will feature vehicular mobile antennas for VHF, UHF, trunking and cellular applications. The Decibel Products Division will show base station antennas for the same frequencies, as well as site management equipment and the Sentry remote site monitor.
Circle 250 See ad page 33, 55, IFC

Aluma Tower **Booths 101, 103, 105**
Existing products
40'-100' aluminum crankup towers.
New products
Disaster recovery tower unit (trailer/shelter/100' crankup tower).
Circle 251

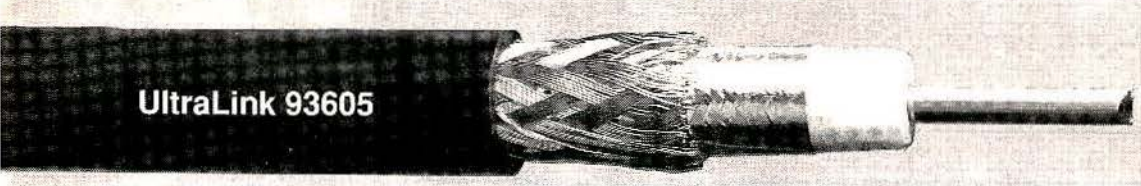
AT&T **Booth 618**
Existing products
E9-1-1 data management and ALI retrieval system; PSAP products; ANI/ALI controllers; management information systems; installation; maintenance; training.
New products
Total digital PSAP.
Circle 252

Avtec **Booths 841, 843**
Existing products
Color touchscreen-operated integrated radiotelephone console systems for control of conventional and trunked radio, telephone, paging and intercom.
New products
DSpatch advanced digital switch that can accommodate 32-1,024 external lines or operator workstations.
Circle 253

Badger Technology **Booth 207**
Existing products
Communications fault management and supervisory equipment.
New products
Graphics Master Station; Badger 2000.
Circle 254

BK Radio (Bendix/King) Booth 226
Existing products
VHF and UHF mobiles and portables; dual trans-

UltraLink Cable®



The New Link For Your Base Stations

- **Solid copper center conductor for excellent conductivity and lowest loss.**
- **Foam dielectric promotes low loss and prevents migration of water.**
- **100% foil shield eliminates RF leakage and decreases the loss of the cable.**
- **95% braid coverage for best connector attachment and excellent grounding.**

UltraLink 93605 is the lowest loss RG213-size cable. 4.19 dB/100 feet at 900 MHz! Compare the loss of UltraLink Base 93605 cable with the others. For many applications it will be your preferred choice.

Order from the factory or your favorite distributor.

1-800-258-3860 • FAX: 1-800-258-3868

THE ANTENNA FARM	ECONOMY TWO-WAY DIST.	PRIMUS ELECTRONICS
CANCOM COMPONENTS	ELECTRO-COMM	RF SERVICES
CMC DISTRIBUTING	GRAHAM RADIO	SANTA FE DISTRIBUTING
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P.O. Box 4680, 48 Perimeter Road, Manchester, NH 03108 • 1-603-627-7877 • FAX: 1-603-627-1764

Circle (29) on Fast Fact Card

ceiver mobiles; signaling devices; full line of accessories.
New products
Flex-mode radios (EMH 5991A, EPH2101A, EPH5102X).
Circle 255 See ad page 29

Cadex Electronics **Booth 747**
Existing products
C3000/C4000 programmable battery analyzers.
Circle 256

California Microwave— TeleCom Transmission Systems **Booth 112**
Existing products
Digital microwave radios in the following capacities: Telestar 2G: 2GHZ—4DSI, 8DSI, 12 DSI; Telestar 6G: 6GHz—4DSI, 8DSI, 12DSI, 1DS3; Telestar 10G: 10GHz—4DSI, 8DSI, 12DSI; MR-15DR: 15GHz—4DSI; MR-18DR: 18GHz—4DSI; MR-22DR: 23GHz—4DSI; MR-40DR: 38GHz—4DSI.
Circle 257

Call One **Booth 341**
Existing products
Telephone headsets and accessories; headset repair services.
New products
ACS—Stratus Ultra convertible headset; UNEX—ProBridge amplifier; GN Netcom Addvantage I headset.
Circle 258

Cast Products **Booths 1024, 1026**
Existing products
Model SH2025 compact speakers; rear deck lights housing; bumper mount speakers; under bumper "partially concealed" speakers.
Circle 259

CD Communications **Booth 141**
Existing products
Training aids for telecommunicators; workbooks; audio tapes; simulated CAD software; seminar training, consulting and research for agencies; Training covers topics for police, fire and medical as they relate to communications.
New products
Interview/assessment center program for new hires into the communications discipline; police, fire, medical single discipline and/or multi-service agencies.
Circle 260

Cellular & Mobile International Booth 1140
Existing products
Published bi-monthly for the international marketplace, *Cellular & Mobile International* provides decision-makers—including public safety communications officers—applications- and equipment-focused articles, as well as news and new product information. The circulation of 10,000+ reaches system operators, dealers, distributors, engineers, large volume end-users and manufacturers in Africa, Australia, Central America, Europe, Far East, Mexico, Middle East, New Zealand and South America.
Circle 261

Cellular Business Booth 1140
Existing products
The first and leading trade publication for the cellular telecommunications industry, *Cellular Business* is published 13 times a year for cellular system operators, dealers, retailers, resellers, sales agents, distributors, engineers, large-volume end-users and manufacturers. The editorial addresses both technological developments and marketing issues, with columns focusing on news, new products, sales strategies and legal affairs. Visit our booth to pick up a copy and sign up for your free subscription.
Circle 262

Celwave Booths 544, 546
Existing products
Selection of antenna system products including base antennas, combining products, system components, transmission line, portable antennas.
New products
DCS systems group—distributed communications systems product.
Circle 263 See ad page 13

Centurion International Booths 1021, 1023
Existing products
Replacement antennas and rechargeable batter-

The New STABILOCK® 4015 Radio Test Set Tests Great–Less Weight

Under $13K/3 Year Warranty

Finally, a two-way radio tester that fits under a helicopter seat, weighs less than 20 lbs., provides all the capabilities you've dreamed of in one unit, and doesn't cost an arm and a leg.

The STABILOCK 4015 packs a lot of features in a compact design:

- ☐ spectrum analyzer with audio
- ☐ electroluminescent display for easy viewing night or day
- ☐ licensed CLEAR CHANNEL LTR® testing capability
- ☐ memory cards to load and run tests automatically, including all cellular formats
- ☐ digital storage oscilloscope
- ☐ internal battery

Lighten your two-way test load today–call for more information on the STABILOCK 4015: **1-800-225-5765 (in MA: 508-671-9700).**

CLEAR CHANNEL LTR is a registered trademark of the EF Johnson Company. STABILOCK 4015 is a registered trademark of Schlumberger Technologies.

NEW OPTION

ERICSSON GE EDACS™

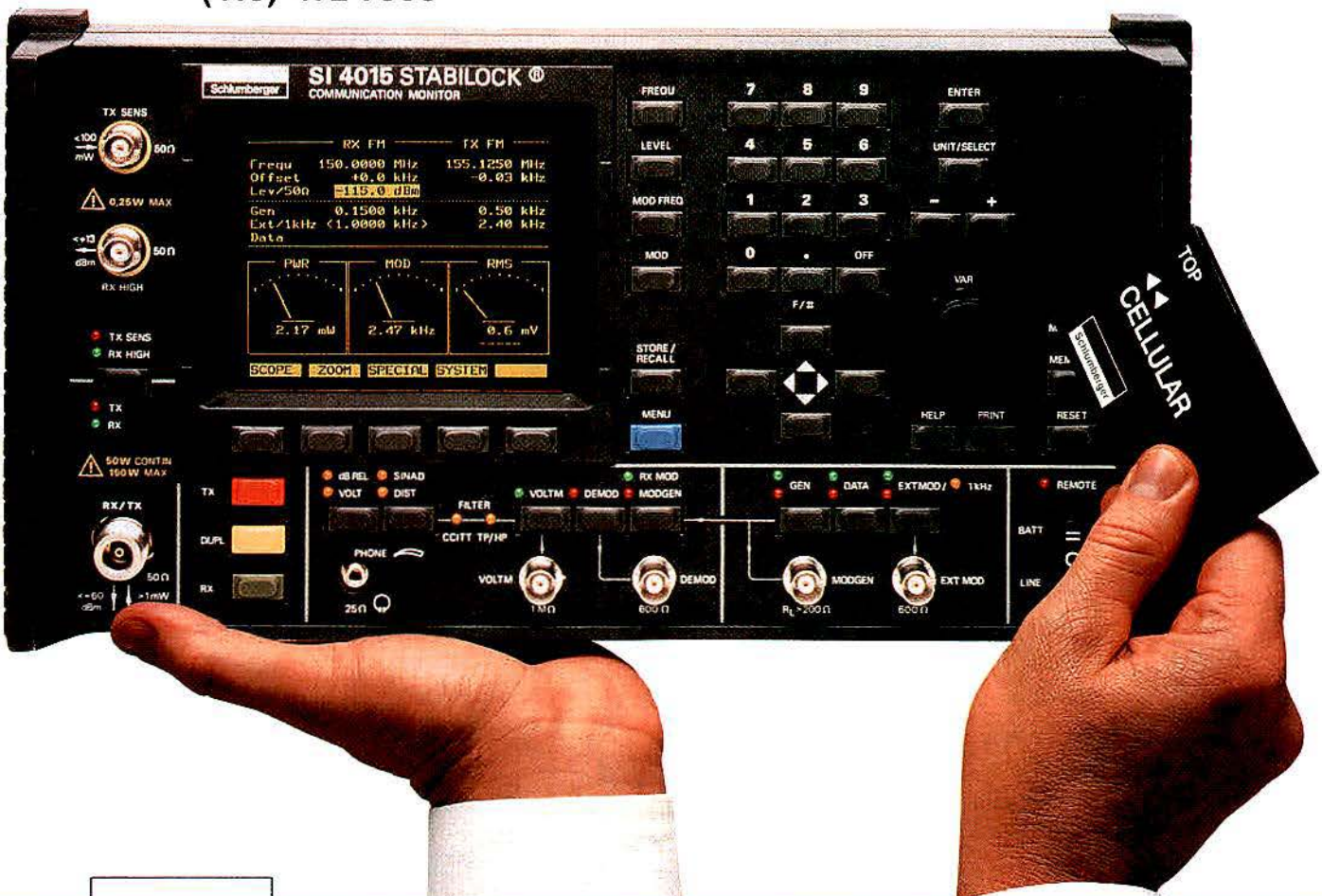
Ericsson GE Mobile Communications Inc.
Mountain View Road • Lynchburg, Virginia 24502

Trunking Licensee

Now in stock at Tessco (410) 472-7000

Quality Test Solutions
Schlumberger Technologies

Schlumberger Instruments
P.O. Box 7004
829 Middlesex Turnpike
Billerica, MA 01821, USA
Phone-508-671-9700
Fax-508-671-9704
1-800-225-5765 (outside MA)



Schlumberger Technologies

Canadian Representative
Atelco Limited
9225 Leslie St. Unit 7
Richmond Hill, Ontario
L4B 3H6
Phone: 416-882-9455
Fax: 416-882-9454

Schlumberger Instruments
Victoria Road
Farnborough, Hampshire
GU14 7PW, England
Phone-44 252 376666
Fax-44 252 543854
Telex-858245

Schlumberger Instruments
50 Avenue Jean Jaurès
BP 620-06
F-92542 Montrouge Cedex, France
Phone-33 1 47 466700
Fax-33 1 47 466727
Telex-631468 ENERINS

Schlumberger Technologies GmbH
Gutenberg Str. 2-4
D-85 737 Ismaning
Germany
Phone-49 89996410
Fax-49 8999641160

Circle (31) on Fast Fact Card

ies for land mobile radios in VHF, UHF and trunking frequencies.
New products
The lowband, broadband EXW antenna that covers 30MHz-88MHz. It is available with a BNX, TNX or SF connector.
Circle 264 See ad page 9

Citadel Computer **Booth 513**
Existing products
MobileStar/486 series of in-vehicle computers for mobile applications that support GPS-navigation, on-board CD-ROM, PCMCIA expansion and wireless data communications.
Circle 265

CML Technologies **Booth 442**
Existing products
Com Node mobile radio dispatch console system; Liberty dispatch console available in desktop or rack-mount configuration.
New products
Liberty-Star dispatch console system that is a cost-effective dispatch system for smaller applications.
Circle 266 See ad page 77

Combined Technologies **Booth 642**
Existing products
Smartswitch II remote comparator displays; TSAY-1 transmitter steering controllers.
New products
MCN series voting receiver displays.
Circle 267 See ad page 80

Communications Technology Associates **Booth 405**
Existing products
Communications consulting in the design and implementation of 800MHz and 900MHz trunking systems, conventional two-way radio systems, transit system, computer-aided dispatch (CAD), automatic vehicle location (AVL), mobile data terminals (MDT), 911/E-911 and dispatch centers.
Circle 268

Connect Systems **Booth 542**
Existing products
CS-800, CS-900, CS-8200, CS-9800 telephone interconnects; CS-6800 radiotelephone remote system; TP-154 shared repeater tone panel; CD-1 CTCSS, DCS, DTMF decoder unit; RT-8 rural telephone system.
New products
Model TP-154 Plus.
Circle 269 See ad page 52

Cylink **Booth 408**
Existing products
AirLink wireless modems.
Circle 270

Dataradio **Booth 144, 144B**
Existing products
Vehicular Information Solutions (VIS) mobile radio modems and datalink controllers for public safety mobile computing applications.
New products
MRM-96+ high-performance mobile radio modem.
Circle 271

Dictaphone **Booth 420**
Existing products
ProLog and Guardian digital communications recording systems; series 6600, series 5700 and series 5900 digital call check and emergency message repeaters.
Circle 272

Digital Recorders **Booths 443, 445**
Existing products
Emergency broadcast systems; highway advisory radio.
New products
Solar Max; Mobile HAR; DR1000 digital recorder/player.
Circle 273

Dispatch Products **Booth 906, 908**
Existing products
200 series consoles; RPS series consoles.
Circle 274

D.M. Data **Booth 137**
Existing products
Computer software for police and fire.
Circle 275

TX RX SYSTEMS INC.

MULTICOUPLER SYSTEMS

RF SYSTEM PRODUCTS

DUPLEXERS

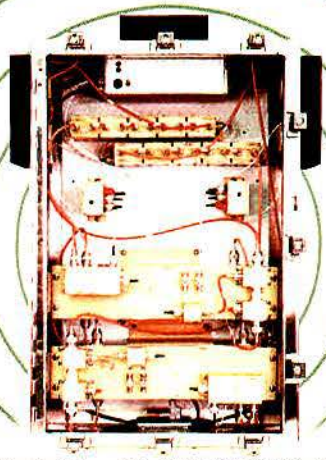
FILTERS

THE "CHUNNEL"

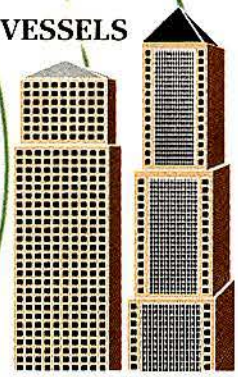
SIGNAL BOOSTER SYSTEMS

SUBWAYS

VESSELS

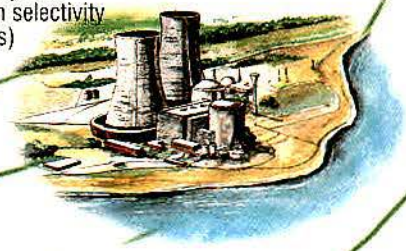


Model No. 61-89A-03-OLC-G2
800 MHz two-way repeater amplifier
(With output level control and high selectivity 8-section combline filters)

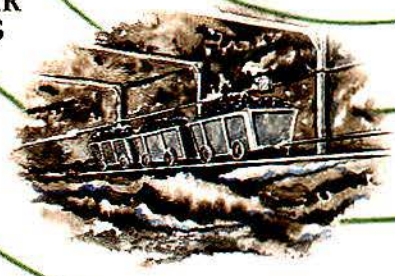


HIGH RISE BUILDINGS

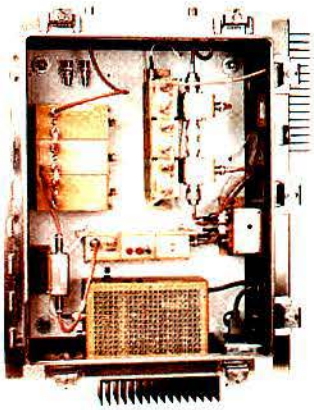
VEHICULAR TUNNELS



INDUSTRIAL STRUCTURES



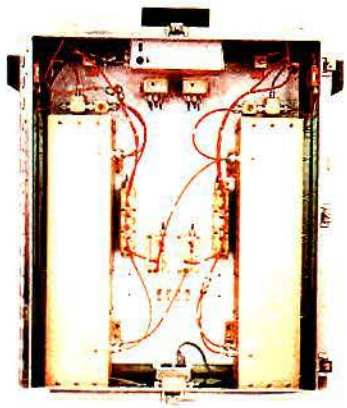
MINES



Model No. 60-38-02-OLC-CF-XX
VHF one way repeater amplifier
(with output level control and crystal filter)

Repeater amplifiers, also known as RF signal boosters, extend radio coverage into areas where abrupt propagation losses prevent reliable communication. We are a leader in the specialized, multidisciplinary field of repeater amplifier system design and manufacturing. We have the distinction of being the first American manufacturer that offered complete, fully integrated repeater amplifier systems.

Since its deployment in 1980, our first system has provided uninterrupted radio service deep inside a coal mine in the Midwest. Thousands of units are in use around the world, as a vital part of two-way radio, paging, radiotelephone, data transmission, telemetry and control systems operating on frequencies from 132 to 960 MHz. Applications include communication systems for major international airports, high-rise buildings, subway systems, copper and coal mines, aircraft carriers, nuclear reactor containment buildings, and the tunnel under the English Channel.



Model No. 61-65-91276
UHF two-way repeater amplifier
(With output level control and high-isolation combline filters)

TX RX SYSTEMS INC. 8625 INDUSTRIAL PARKWAY, ANGOLA, NY 14006
TELEPHONE 716-549-4700 FAX 716-549-4772 (24 HRS.)

DX Radio Systems **Booth 149**
Existing products
RTF series repeaters and base stations; RTP series portable repeaters; DXP series paging transmitters; telephone links.
New products
Eclipse series repeaters and base stations.
Circle 276 See ad page 73

Dynamic Instruments **Booth 1006, 1008**
Existing products
DI-939 digital recording system.
New products
DI-934 remote interface terminals.
Circle 277

E.F. Johnson **Booth 326**
Existing products
Multi-Net system product line: Summit QX 2008 repeater; Summit DM (MM81-83/91-93) mobiles; model 5876 LTR and conventional UHF hand-helds; Viking CK-HM81 Multi-Net/LTR/conventional hand-helds.
New products
Multi-Net II enhanced wide-area public safety system, including redesigned consoles and system management packages; Viking CK-HM83 Multi-Net/LTR/conventional 3W hand-helds; Viking CM-HM83 Multi-Net/LTR/conventional 3W hand-helds; Viking CT-HM81 Multi-Net/LTR/conventional full-duplex hand-helds; Multi-Net accessories, including new control station and desk microphone; conventional console products; Avenger SE-(HC13) VHF/UHF 5W hand-helds; Avenger GX (MC11/12) VHF mobiles.
Circle 278 See ad page 53

ElectroCom Communication Systems **Booth 232**
Existing products
Model 890 mobile data computer; 101 radio data controller; trunked radio data interface.
New products
Diversity reception controller; transmit fast alarm indicator.
Circle 279 See ad page 83

Emergency Mecical Services Magazine **Booth 200**
Existing products
Magazines.
New products
EMS Trivia 2 game; *Tricks of the Trade* video; *The Best of Case Review*, volume 1 book.
Circle 280

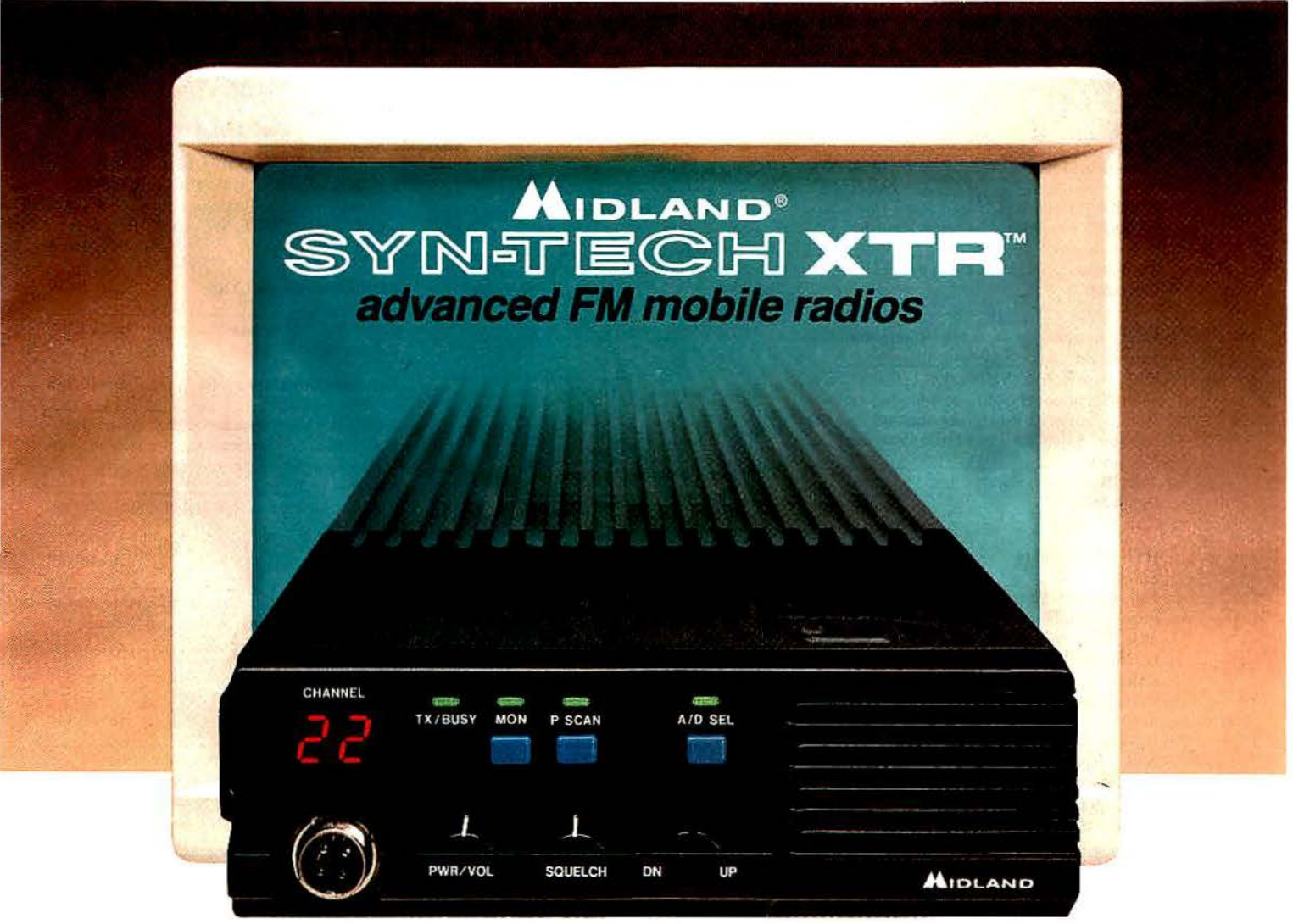
ERI—Electronics Research **Booth 800**
Existing products
Guyed towers; self-supporting towers; monopoles; structural engineering services; site construction services.
New products
Cell-thru antenna mounting system.
Circle 281

Flash Technology **Booth 517**
Existing products
Strobe lighting systems and products—medium intensity FTB 310; FTB 311; FTB 330; FTB 331.
Circle 282

Fleet Safety Equipment **Booth 1012**
Existing products
Pursuit Control Centers (PCC) six and ten switch; 9000 series lightbar; 4000 series lightbar; floor stack brackets; prisoner transport seat; complete emergency systems.
New products
Pursuit Control Centers (PCC): 4000/8SIFST—maintenance-friendly lightbar; FS1200 series floor stack brackets.
Circle 283

Gamber-Johnson **Booths 541, 543**
Existing products
Mission Control air bag-friendly mounting system for voice and data communications equipment; DS series mounting hardware; Stackmaster; Floormaster; Superslide; Command Post; power distribution accessories.
Circle 284 See ad page 40

GE Capital Public Finance **Booth 942**
Existing products
Tax-exempt lease-purchase financing.
Circle 285



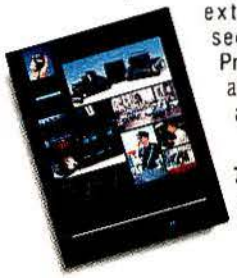
Think of it as a mobile "workstation" that delivers everything on the menu.

Performance

All the essentials you need to get the most from your system. Excellent Tx/Rx specs in lowband, VHF, UHF and 800 MHz models. 22 or 99 channels. Up to 110 Watts. 10 Watt external audio. TOT. BCLO. 41 tone and 83 digital squelch codes. Fast 40 channels/second priority scan.

Versatility

These compact radios give you exceptional operational flexibility with a broad range of options, accessories and programming choices. Repeater talk-around for direct mobile-to-mobile communications. Built-in modem optimizes data communications: no extra boxes. High-security scrambling. Practically any digital and/or analog signaling and selective calling formats you need, including DTMF/ANI. Voice storage/message relay acts as a "mobile answering machine", range extender for portable radios, or both. Plus both programmable conventional and software trunking capability. 12.5 kHz channel kits, too.



To learn more about how the XTRordinary Syn-Tech XTR radios can improve your operations, ask for this free brochure today!

User Friendly Operation

Syn-Tech XTR radios are easy to use. Over 20 logical control panel options to exactly match your system requirements and the radio options you choose. Even dual controls.

Durability

All models have rugged die-cast chassis and meet U.S. military specs for shock & vibration (MIL 810C/D). MIL SPEC protection against salt-fog, rain and dust also available.

Reliability

Projected failure-free service life is an average of over 20 years of regular 40-hour work weeks per unit.

Value

Syn-Tech XTR radios deliver that rare combination of essential performance features, versatility, quality and reliability at reasonable cost. Backed by Midland's nationwide Sales & Service network, and responsive factory technical support when you need it.

1-800/MIDLAND (Ext. 1690)
In Canada: 905/839-1700

MIDLAND LAND MOBILE RADIO LMR

Circle (35) on Fast Fact Card

Harris Farinon **Booth 818**
Existing products
DVM6-8T expandable digital microwave radio; DVM6-45 Excell digital microwave radio.
New products
StarScan network management system.
Circle 286

Hitech Systems **Booths 806, 808**
Existing products
SafetyNet CAD, Safety E9-1-1 interface; SafetyNet mapping interface; SafetyNet message switch; SafetyNet emergency medical dispatch interface; SafetyNet mobile data interface.
New products
SafetyNet records management system.
Circle 287

HTE Public Safety **Booth 807**
Existing products
Fully integrated set of applications that use terminology familiar to the agency through a soft-code, table-driven concept designed to provide the customer with the ability to build unique, consistent responses to mandatory data fields; Crimes record management; parking enforcement; CAD III—Computer Aided Dispatch; CAD redundancy; E9-1-1 interface; crackdown; AVL mapping; GIS interface; image processing—photo image processing—documents; Fires 2000; and Fire Prevention Service.
Circle 288

Hughey & Phillips **Booth 940**
Existing products
FAA-approved obstruction lighting for tall towers.
New products
Flashguard 2000 and Flashguard 3000 strobe lights.
Circle 289

IFR Systems **Booth 441**
Existing products
Communications service monitors; spectrum analyzers.
Circle 290 See ad page 57

Informer Computer Systems **Booth 918**
Existing products
Informer 9-1-1 family of automatic location identification monitors, including CRT, EL and color.
New products
Informer CallTracker gathers data from the IA2 system and consolidates IA2 and 9-1-1 controller data.
Circle 291

Kenwood Communications **Booths 1048, 1050, 1149, 1151**
Existing products
Conventional portables, mobiles, base stations, repeaters; full line of trunked portables, mobiles and repeaters; options and accessories for all product lines.
New products
Kenwood TK-250 (VHF) and TK-350 (UHF) portable radios; MILSTD 810 C, D & E—32-160 channels, wideband design ensures full bandwidth coverage. VHF: 5W max./UHF: 4W max.
Circle 292 See ad page 59

LDV/Lynch Display Vans **Booth 1030**
Existing products
Command center; Haz-Mat/rescue vehicles.
Circle 293

LeBlanc Communications **Booth 946**
Existing products
Emergency restoration services; systems integration; installation and maintenance support; self-supporting, guyed and monopole towers.
New products
Quik Quote tower design and proposal software.
Circle 294

MaSys **Booth 440**
Existing products
Enfors/CAD public safety system; other demonstrations available for records, jail systems.
New products
Enfors/mapping.
Circle 295

Microwave Data Systems **Booth 118**
Existing products
MDS 960A analog point-to-point radio.
New products
MDS 450D/950D digital point-to-point radio.
Circle 296

DESIGNED FOR DISPATCH

5 REASONS TO BUY A TDD DESIGNED FOR YOUR DISPATCH CENTER

ONE
TWO
THREE
FOUR
FIVE

CAD INTERFACE

Zetron's Model 3030 PSAP TDD comes standard with a RS-232 port that lets it be used with most CAD systems. Allows dispatch operators to use their existing Computer Aided Dispatch (CAD) keyboard and CRT display for handling TDD calls.

AUTOMATIC CONFIGURATION FOR MODE (ASCII/BAUDOT) AND BAUD RATE

Zetron's Model 3030 lets your operators handle any type of incoming TDD call, including ASCII, with complete confidence. Most other TDDs require operator selected modes that are confusing and waste time in critical situations.

TRANSFER OF ASCII CALLS TO SECONDARY PSAPS

Zetron's Model 3030F PSAP TDD is the only unit on the market that can transfer an ASCII call to a secondary PSAP without dropping the call.

FLEXIBLE MOUNTING

Zetron's Model 3030 can be directly mounted in Motorola CentraComm II console channel modules or in 19" x 5.25" rack adapters, or in a heavy duty desktop enclosure. Allows writing surfaces to be kept free of clutter and TDD equipment ready for service when needed.

DIRECT CONNECTION TO ELECTRONIC TELEPHONE INSTRUMENTS

A Telephone Handset Adapter lets the Model 3030 be directly connected to almost any phone system without the limitations of klunky accoustic couplers.

For more reasons to buy Zetron's PSAP Equipment, call us today!

ZETRON®

12335 134th Ct. N.E. Redmond WA 98052 Ph: (206) 820-6363 Fax: (206) 820-7031

APCO

Midland Land Mobile Radio — Booth 720

Existing products

XTR series mobile and portable radios; Syn-Tech II mobiles and base stations; Base-Tech base stations and repeaters; Syn-Tech II vehicular repeaters.

New products

Midland 70-147, 22-channel portable; Midland 70-148, 99-channel portable.

Circle 297 — See ad page 41

Mobile Radio Technology — Booth 1140

Existing products

Mobile Radio Technology is recognized as the leading source of technology-focused industry guidance. Readers include public safety communications officers, large-volume end-users at government, transportation, business and industrial agencies, as well as mobile radio dealers and service shops, paging and SMR service providers, and manufacturers and their reps and distributors. The editorial addresses the latest in equipment and applications, business developments, legal and regulatory matters. Visit our booth to pick up a copy and sign up for your free subscription.

Circle 298

Northpoint Communications Products — Booth 507

Existing products

Low-profile mobile antennas available for all cellular, UHF and SMR mobile applications.

New products

LoPro mobile antennas: Models NP4000 and NP4500 cover UHF frequency ranges; NP8000 covers cellular frequency range; NP8500 covers SMR frequency range.

Circle 299

Orbacom Systems — Booths 733, 735, 737

Existing products

The TDM-150 series distributed microprocessor console systems, including module-based, CRT-based with touchscreen, mouse or trackball operation and furniture.

New products

The Calida+ desktop console—the Calida with additional features and capabilities.

Circle 300 — See ad page 27

PacketCluster Systems — Booths 1043, 1045

Existing products

Mobile data communications systems for public safety.

New products

Mobile data systems with CAD/RMS interface and automatic vehicle location.

Circle 301

Pagetek — Booth 907

Existing products

Protek-24 remote monitor, alert and control system; Protek-Jr. remote monitor, alert and control system.

New products

The Protektor tower light alarm system.

Circle 302 — See classified ads

Plant Equipment — Booth 218

Existing products

Electrokey; MAARS (Modular ANI/ALI Retrieval System); Comcentrex; MAARS-View.

New products

Vesta combines computer technology with telephony services to provide a solution to the growing needs of the modern call taker.

Circle 303

PolyPhaser — Booths 644, 646

Existing products

Grounding and "lightning arrestor" products for coax, twisted pair ac and dc power.

New products

3 Peep earthed entrance panel; Uni-Kit 2 grounding kit; IS-CT50HN cellular coaxial lightning "arrestor" with sampling port; IS-PM240 safety approve ac power lightning "arrestor."

Circle 304 — See ad page 86

Public Safety Systems — Booths 219-229

Existing products

Computer-aided dispatch; records management; crime analysis; investigative management systems.

Circle 305

Racal Recorders — Booths 748, 750

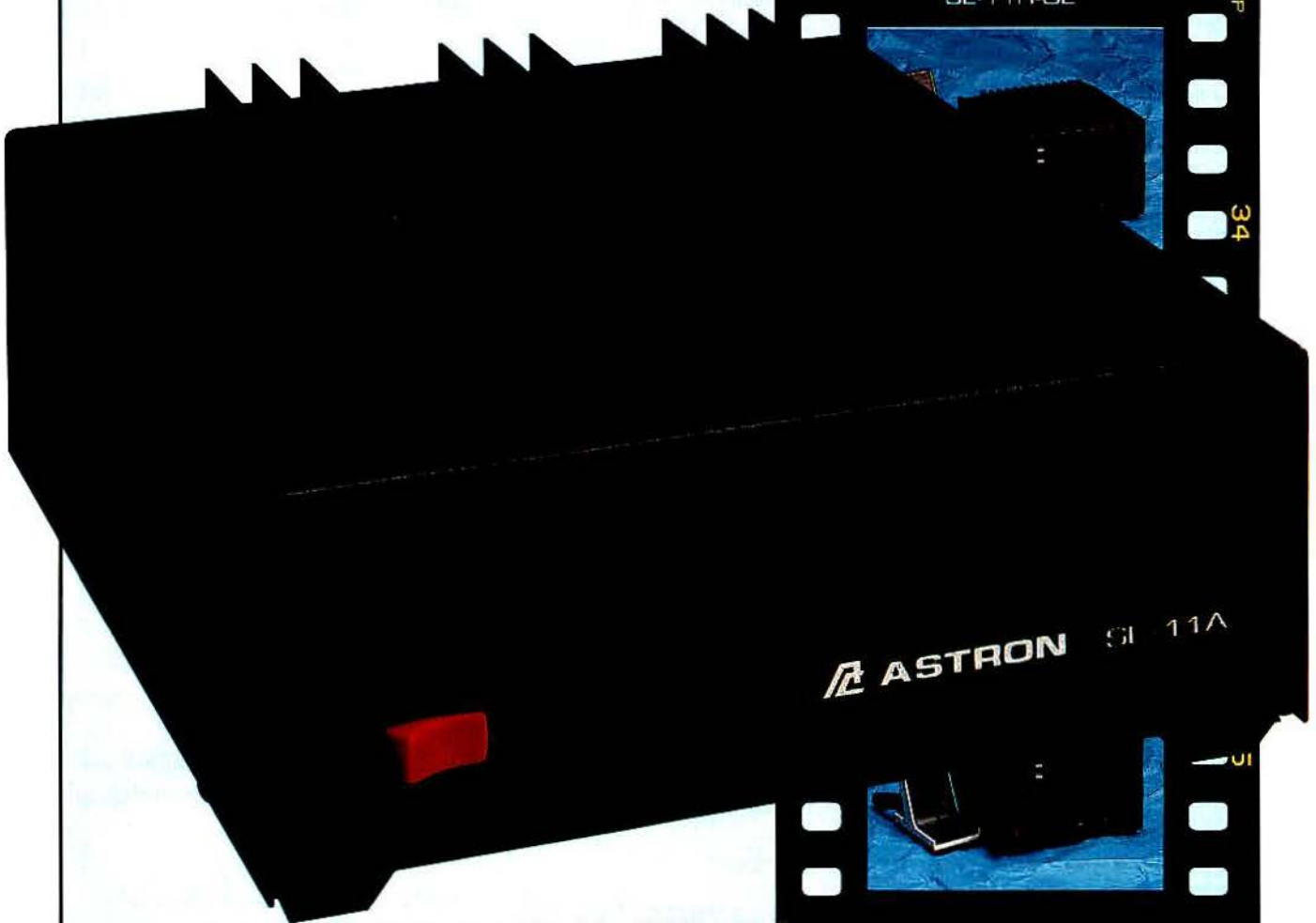
Existing products

POWER ON . . . with ASTRON.

Astron Corporation is the leading manufacturer of high-quality power supplies and converters for the land mobile industry.

With the new SL-11 series of low profile power supplies, specifically designed for base station applications, the setup is simple, easy and looks attractive. Just mount the radio, with the mounting pads (supplied with the power supply), to the top of the SL-11A (2¾"H x 7⅝"W x 9¾"D) or the SL-11R (2¾"H x 7"W x 9¾"D). The power supplies are very well regulated and will provide 11 amps of current at a 50% duty cycle. The units have fold-back current limiting to protect them from overload and short circuit, and an overvoltage protection feature to protect the radio should the output voltage exceed a safe level. All SL series units are available in dark gray or black.

Power supplies and converters from Astron: our unsurpassed quality and reliability have made us the #1 choice in the communications industry.



ASTRON CORPORATION
9 Autry, Irvine, CA 92718
Telephone: 714/458-7277
Facsimile: 714/458-0826

WordSafe; WordSafe Maxima; Model 22.
New products
Rapidax Ranger.
Circle 306

RAM/BSE **Booths 844, 846, 943, 945, 947**
Systems Development
Existing products
Integrated public safety solutions; project management and applications including: CAD, RMS, message switching, intelligent workstations, public (Mobitex) and private mobile data systems, GIS, wireless mail system.
Circle 307

RAM Communications Consultants **Booth 840**
Existing products
Full-service consulting company that specializes in public safety communications systems, including E9-1-1, CAD, AVL, addressing, mapping and communications center design.
Circle 308 See classified ads

RAM Mobile Data **Booths 844-850, 945-951**
Existing products
Wireless data communications solutions, including related professional services and support to state, regional and local police departments. Software applications include host-driven, real-time computer-aided dispatch; records management/incident reporting; uniform crime reporting; criminal justice information; automated vehicle location; messaging and imaging. Hardware includes vehicle-mounted or hand-held pen-based terminals or terminals with keyboards.
Circle 309

Rehn Communications **Booth 1041**
Existing products
WHS series VHF & UHF portable scanning radios; PT series VHF & UHF portable radios; RSP series VHF & UHF portable scanning radios; RM series, SM series lowband, VHF & UHF mobile scanning radios; SL series VHF & UHF mobile radios.
New products
WHS150 VHF portable scanning radios; WHS450 UHF portable scanning radios; UC2200 VHF portable radios; UC4200 UHF portable radios; SMV4016, SMV4099 VHF mobile scanning two-way radios; SMU2516, SMU2599 UHF mobile scanning two-way radios.
Circle 310 See ad page 90, IBC

***Rescue 911*/Katy** **Booth 404**
Film Productions
Circle 311

Rohn **Booth 640**
Existing products
Self-supporting towers; guyed towers; concrete equipment shelters; fiberglass equipment shelters; concrete poles; steel poles; walk-in equipment cabinets.
Circle 312

Sabre Communications **Booth 147**
Existing products
Full line of both guyed and self-supporting towers, as well as complete turnkey installation services.
Circle 313

Scala Electronic **Booth 349**
Existing products
Americell panel antennas, 90°, 105° for trunking systems; Miniflector and Panaflector antennas for point-to-point 960MHz and spread-spectrum applications; Omni antennas for trunking, two-way, paging and indoor communications.
New products
65° Americell panel antenna for trunking applications; wall-mount indoor antenna for paging and trunking systems.
Circle 314

Schlumberger Technologies **Booth 201**
Existing products
4015 Stabilock radio test set with EDACS software.
New products
4032 Stabilock with high-speed spectrum analyzer.
Circle 315 See ad page 37

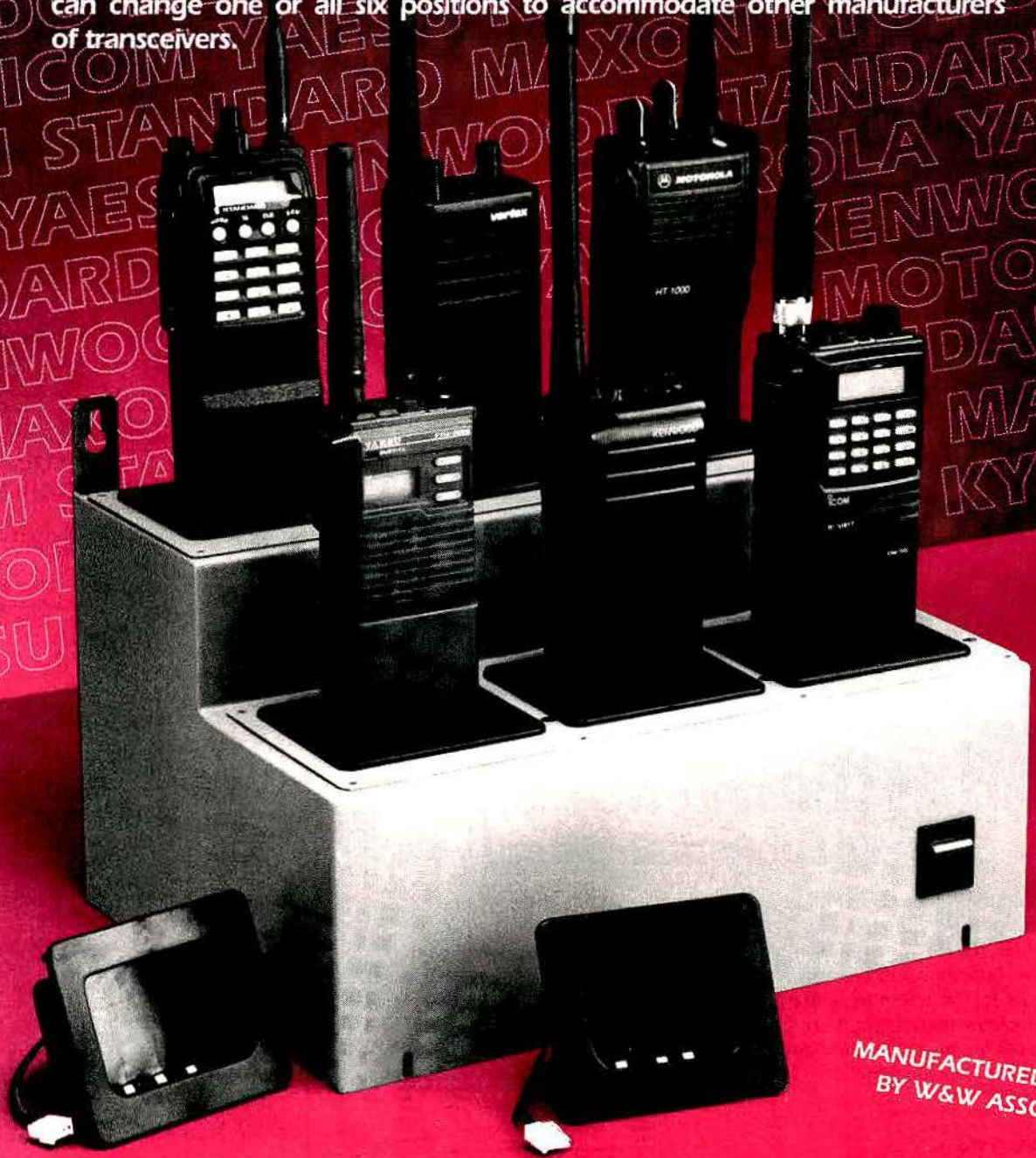
Scientific Dimensions **Booth 134**
Existing products
SDI slide mounts; SDI series 5000 modular

MasterCharger 6

A New Concept in Chargers

Now You Can Charge 6 Different Batteries Simultaneously!

MasterCharger 6. . . a revolutionary new charger that can charge six different batteries simultaneously, with different voltages and capacities – nickel cadmium or nickel-metal hydride...it doesn't make a difference! In addition, you decide which batteries you wish to charge: Motorola, Yaesu/Vertex, Kenwood, Icom, Standard, Maxon, Kyodo, Relm, etc. You can mix different manufacturers and if at a later date, if so desired, you can change one or all six positions to accommodate other manufacturers of transceivers.



MANUFACTURED IN U.S.A. BY W&W ASSOCIATES

W & W ASSOCIATES

800 SOUTH BROADWAY, HICKSVILLE, NEW YORK 11801

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ALL SPECIFICATIONS & PRICES ARE SUBJECT TO CHANGE WITHOUT NOTICE

Circle (41) on Fast Fact Card

mounting systems; SDI 6000 universal portable mount; SDI 7000 MDT mounts.
New products
SDI 7200 console mount; SDI 7800 Safe Zone templates; SDI series 1500 flexible mounts; SDI 7300/7400 cage box/bracket.
Circle 316 See classified ads

Sel-Tronics **Booth 912**
Existing products
E1000 digital voice logger/playback monitor remote control.
New products
Model E101R multi-station instant recall.
Circle 317

Skaggs Telecommunications Service **Booth 504**
Existing products
Specialty vehicles—surveillance vehicles, police cruisers, security cruisers; electronic equipment furniture—modular consoles, command centers, dispatch centers; surveillance vehicle modules that can be used in multiple vehicle applications.
New products
STS surveillance vehicle module; 2700 Visual Patrol in-car video unit; component console—moveable countertop version.
Circle 318

SKC Communication Products **Booth 802**
Existing products
Plantronics headsets.
New products
Plantronics noise-canceling (H31N, H51N, H61N) telephone headsets.
Circle 319

Slattery Software **Booth 805**
Existing products
FCC licensing software—Forms 574, 402, 401A, 401B and 494.
New products
FCC licensing software, version 6, for laser printers.
Circle 320

SMC Electo-Mount Booths 300, 302
Existing products
VCC series vehicular communications consoles; S2000 series stack mounts, MDT mounts, laptop mounts.
New products
VCC-EX vehicular communications console; VMSA-SM laptop computer mounting system with lock; EMDT-1 ElectroCom MDT mount system; MOMD-T Motorola 9100 MDT mount system.
Circle 321 See ad page 60

Sonic Communications Booth 347
Existing products
Line of headsets; ear microphones; throat microphones; surveillance kits; motorcycle and auto racing accessories; wireless communication accessories.
New products
MIB 101 mobile interface box; DSC 101 dispatch system controller.
Circle 322 See ad page 22

Spectracom **Booth 305**
Existing products
Netclock/2 NIST synchronized clock; 8176 large display clock.
New products
TimeTap time distribution module; TimeGuard clock monitor/selector; TimeTalk synchronized talking clock used with analog voice loggers.
Circle 323

Spilsbury Communications **Booth 705**
Existing products
DVR1001 digital instant voice recall recorder; DVR2001 digital instant voice recall recorder; SBX11A portable HF/SSB bush radio.
Circle 324

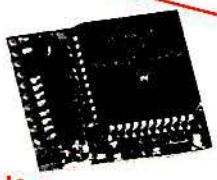
Stancil Booth 540
Existing products
Recall/PBR series VHS 32-track logging recorders; SIR series solid-state instant recall.
New products
Gemini series DAT 32-track digital logging recorder.
Circle 325 See ad page 63

Stanilite Electronics **Booths 100, 102**
Existing products

4 New Winners from Midian

$59.95

Model ANI-U



Smallest Multi-Format, Multi Feature ANI with optional CTCSS encode

- ANIs: DTMF, CCIR, ZVEI, DZVEI, DDZVEI, NATEL, EEA, EIA, & MODAT®
- Optional 51 code CTCSS encoder
- Delayed CTCSS for inaudible ANI
- User-programmable tone timings
- Leading and/or Trailing ANI with mic mute
- Programmable ANI repeat delay timer
- Emergency ANI with repeat timer
- Emergency ANI "man down" delay timer
- Emergency Ear™ monitor timer
- Programmable ANI speed & front porch delay
- Programmable Busy Lockout
- Timeout Timer with stuck mic alert tone
- Available for Midian Zap™ & GE-Star®
- digital ANI formats (DFA-1/DFA-2)
- Dimensions: 1.1" x .88" x .22"

Model RT-8X/TRA

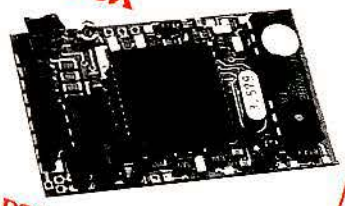
RTX-compatible Telephone to Radio Adapter

- Converts standard telephone with RJ11 connector to radiotelephone formats, rural phone, or extended phones when interfaced with simplex or duplex radio
- Full/Half-duplex or VOX capability
- Outputs 90 Volts to ring standard telephone bell
- Built-in dial and busy tones
- Programmable via telephone Touch Tone® keypad
- 1-12 digit connect and disconnect ANI
- 10 number memory dialer with last number redial
- Also available for DTMF interconnect applications

$269.95

$99.95

Model RT-8X

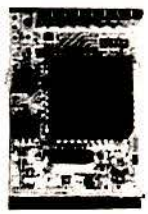


Programmable DTMF Encoder/Decoder Compatible with RTX

- Three programmable decode numbers for selective calling with multiple ring codes
- 1–12 digit connect and disconnect ANI
- Ten number memory dial, last number redial
- Call routing digit for CES or RTX mobile call
- Trunking delay for connect ANI
- Time Out Timer & Busy Channel Lockout
- Carrier refresh for base or repeater COR/COS
- CTCSS encoder with programmable modulation
- Deadbeat Disable for lost or stolen radios
- Programmable channel scanning
- Timed automatic disconnect
- Forced decode reset
- Dimensions: 1.84" x 1.2" x .25"

Ready to Deal?

Model ID-1



Keyboard Programmable Morse Identifier

- All messages & features programmable via 12-button Touch Tone®-style keypad with alphanumeric characters
- Sends 16-character station ID or 130-character message at programmable repeat intervals and speed
- Programmable front porch keyup delay
- Programmable morse tone freq. (1 to 3000 Hz)
- Programmable wait time after COR loss
- Can send morse tone manually
- Dimensions: 1.4" x 1.1" x .25"

$79.95

To Order Call Toll Free: 1-800-MIDIAN'S

Corporate Headquarters: (602) 884-7981 FAX: (602) 884-0422

MIDIAN

World Leader in Innovative Communications Technology

MIDIAN ELECTRONICS, INC. / 2302 East 22nd Street / Tucson, Arizona 85713

Circle (44) on Fast Fact Card

PERFORMANCE EVALUATION

Name : everReach

Current Position:
New Pager in U.S. Market

Review Period:
Jan. 1994 until Jun. '94.

Achievement:
Shipments totalling 52,924 pagers in only 6 months

Performance:
Highly reliable (Average return rate per month : 0.01%)

Responsibility:
- Reasonable price and easy after sales service
- Provides a full 18 months warranty for users

Number One Skill:
Catches every signal – Highly sensitive

Capabilities:
Small and light (compact design)
Power back up
Automatic power on/off
Time Stamping
20 message memory
Both VHF and 900 MHZ available.
512/1200/2400 BPS
Duplicate message check
Alarm

Remarks: A synthesized and an alphanumeric type will work together to establish the best team by the 3rd quarter in 1994.

Evaluation Rating:
Excellent Performance

Evaluator:

Representative Customer

Excellent performance puts 100% satisfaction in your customers' pockets and profits in your

EVERON
AMERICA, INC.

TEL: (800) 603-3766 FAX: (601) 949-3349
FCC CODE NO. KSCEP-110 FOR VHF
FCC CODE NO. KSCEP-010 FOR UHF
IC (DOC) CODE NO. 2187 101 145 FOR VHF
IC (DOC) CODE NO. 2187 101 147 FOR UHF

Circle (45) on Fast Fact Card

Digital trunking products and systems.
New products
Wide-area digital trunking systems.
Circle 326

Sti-Co Industries **Booths 447, 449**
Existing products
Disguised mobile two-way antennas, including custom fender-mount lowband, highband, UHF and broadband models; cellular look-alike VHF, UHF and dualband antennas; low-profile transit antennas; special use antennas; couplers; tuners; dual matched systems.
New products
Custom fender-mount disguised antenna for Euro-Asian car models, including Nissan Sentra, Quest, Altima, Stanza and Pathfinder; Mazda MPV and Navajo; Toyota Previa and T-100; Volkswagen Golf and Jetta; Isuzu Rodeo; custom fender-mount disguised antennas for 1994 American car models; hatchback adapter for non-elevated feed cellular look-alike antennas.
Circle 327 See ad page 42

Swager Communications **Booth 209**
Existing products
Dura towers; Climber's buddy safety climbing equipment.
Circle 328

TEAC America **Booths 414-416**
Existing products
DCR-4200T digital tape communications recorder; DCR-4200D digital optical disk communication recorder; DCR-4000R digital network controller; CR-300 VHS communication recorder.
New products
CR-400 digital communication recorder.
Circle 329

Telex Communications **Booth 606**
Existing products
Ear Mikes; headsets; Magnacom and MagnaRope intercoms.
New products
EC-100 Ear Mike for security market; directly interfaceable headset line.
Circle 330

Tessco **Booth 412**
Existing products
SDI 7200; Gamber-Johnson console mount; tool case kit; pager accessories; microphone; Fluke 77.
New products
SMC VCCEX series.
Circle 331

Tiburon **Booths 518, 520, 522**
Existing products
CAD/2000 computer-aided dispatch (Windows and GUI); RMS/2000 records management system.
New products
MDC/2000 mobile data computing.
Circle 332

Times Microwave Systems **Booths 1002, 1004**
Existing products
LMR flexible communications coax; nu-Trac triaxial antenna cable.
New products
Plenum-rated versions of LMR cables; cable prep tools for LMR cables; LMR-900 5/8" low-loss cable—spanning the gap between 1/2" and 7/8".
Circle 333 See ad page 21

TPL Communications **Booth 149**
Existing products
RF power amplifiers, mobile, base station and repeater; mobile amplifier chargers; power output levels as high as 500W with milliwatt input levels.
Circle 334

Transcrypt International **Booths 619, 621**
Existing products
Crypto Voice Plus (CVP) scrambler modules; FlashCall signaling modules.
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Circle 335 See ad page 3

Trimble Navigation **Booths 920, 922**
Existing products

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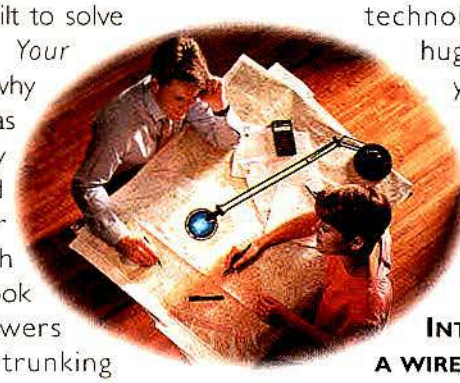

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PCVtrak.
Circle 336 See ad page 61

TRW **Booth 926**
Existing products
Systems engineering, development and integration, including RF communications, automated identification systems and emergency operations and communications centers.
New products
Emergency warning reciever includes an EBS-compatible receiver, a NOAA-compatible receiver and a third CSEPP-compliant, DTMF-addressable receiver with a loud alert tone.
Circle 337

TWR Lighting **Booth 708**
Existing products
Red light tower lighting systems; white light tower lighting systems; obstruction lights.
New products
Low-voltage strobe light system.
Circle 338

Tx Rx Systems Booth 512
Existing products
Duplexers; resonant cavity filters; multicouplers; signal boosters; RF system products and associated hardware.
Circle 339 See ad page 39

Valmont Industries **Booth 641**
Existing products
Monopoles; freestanding and guyed towers; installation services.
New products
Camouflaged poles—"tree" pole, "cross" pole.
Circle 340

Vega Booth 448
Existing products
C-5112 ten-line remote console; C-1614 six-line, four-frequency remote console; 1223C tone remote adapter panel.
New products
C-1614R rack-mount six-line, four-frequency tone remote; XP-2 cross-patch for C-5112 ten-line remote console.
Circle 341 See ad page 1

Warning Systems **Booth 346**
Existing products
Onalert tone alert radio receivers; Warnalert.
Circle 342

Whelen Engineering **Booths 301, 303**
Existing products
Controls for public warning systems: E-864 MP encoder status display and printer; Commstay Commander; ECP864 event control panel; WPS-2800-4 high-power voice and siren system; emergency vehicle siren and lighting products; Edge series lightbar traffic advisor.
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VA-2000 alert monitor and message display; self-container Dash-Miser series warning lights.
Circle 343

WirelessWorld magazine **Booth 1140**
Existing products
The new quarterly, published by the same people who bring you *Mobile Radio Technology* and *Cellular Business*, provides market updates, engineering information, applications stories and the latest news for the wireless communications industry. It is written for personal communications services (PCS) license applicants, operators of cellular, paging and SMR systems, as well as radio common carriers, large-volume end-users, including local area network (LAN) managers, manufacturers and their reps and distributors. The 1994 WirelessWorld Conference & Exposition will be held in Orlando, FL, on Oct. 3-5. Call 913-967-1856 to attend.
Circle 344

Zetron Booths 740, 742
Existing products
Series 4000 communication control system; 4010, 4016, 4018, 4118 radio dispatch consoles; 4217 video console; 3022, 20, 21 and 921 instant recall recorders; 6/26 fire station alerting system; 16, 24, and 25 programmable encoders.
New products
Model 28 AudioMaster.
Circle 345 See ad page 43, 81, 89

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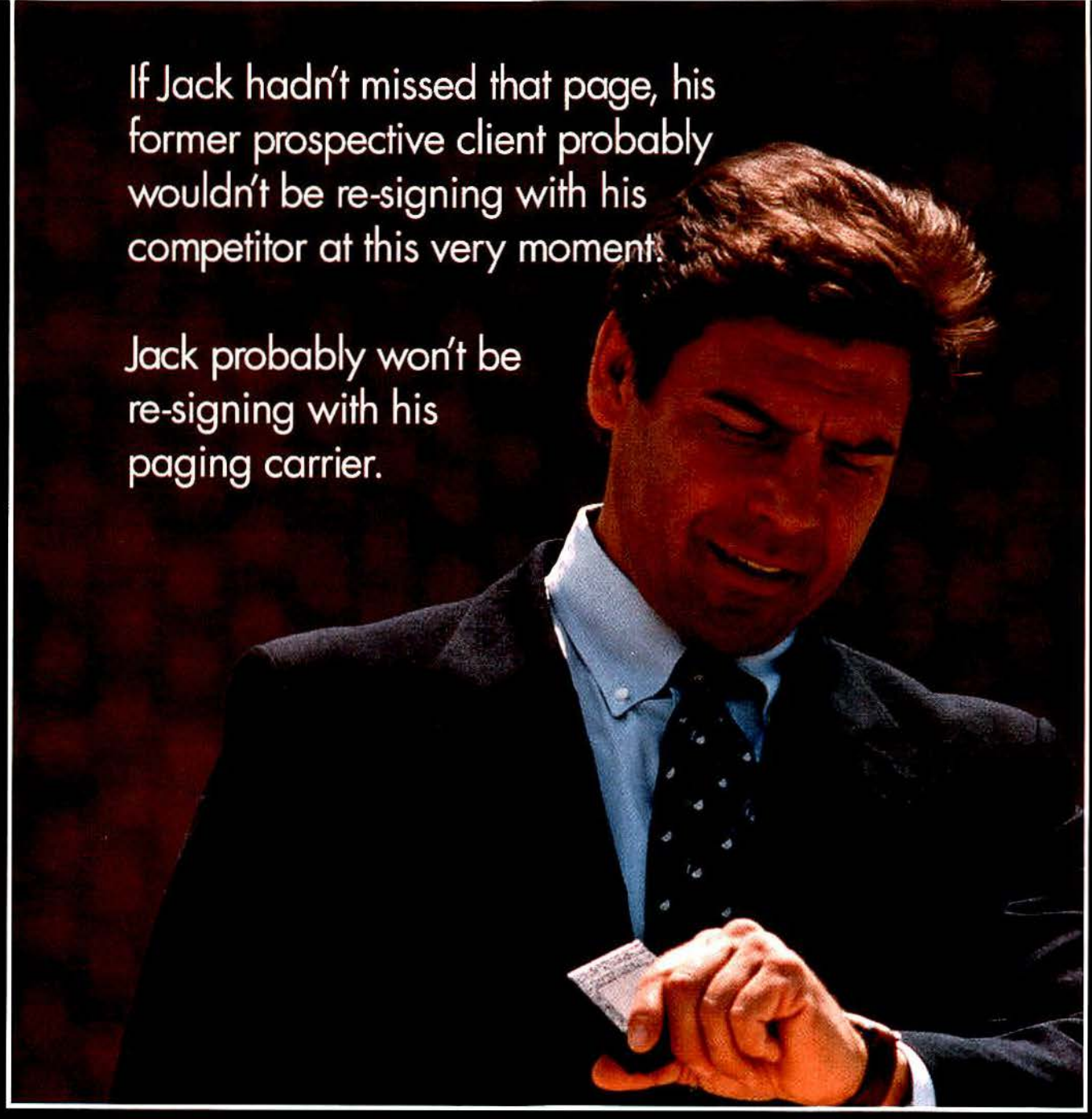

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Technically speaking

continued from page 8

1) $D = \sqrt{2h}$

where D = line of sight distance to horizon in miles
h = tower height in feet

2) $D = \sqrt{2h_1} + \sqrt{2h_2}$

where D = line of sight distance between two towers in miles
h_1 = height of first tower in feet
h_2 = height of second tower in feet

3) $r_1 = 31.67\sqrt{\frac{\lambda D_1 D_2}{D_1 + D_2}}$

where r_1 = first Fresnel zone in meters
λ = wavelength in meters
D_1 = shorter distance in kilometers
D_2 = longer distance in kilometers

4) $r_1 = 548.33\sqrt{\frac{D_1 D_2}{F(D_1 + D_2)}}$

where r_1 = first Fresnel zone in meters
F = frequency in MHz
D_1 = shorter distance in kilometers
D_2 = longer distance in kilometers

5) $r_1 = 2{,}280\sqrt{\frac{D_1 D_2}{F(D_1 + D_2)}}$

where r_1 = first Fresnel zone in meters
F = frequency in MHz
D_1 = shorter distance in miles
D_2 = longer distance in miles

6) $L = 20\log D + 20\log F + 32.3$

where L = free-space path loss in decibels between halfwave dipoles
D = distance in miles
F = frequency in MHz

7) $r_N = r_1\sqrt{N}$

where r_N = Nth Fresnel zone
r_1 = first Fresnel zone
N = integer (2, 3, . . .)

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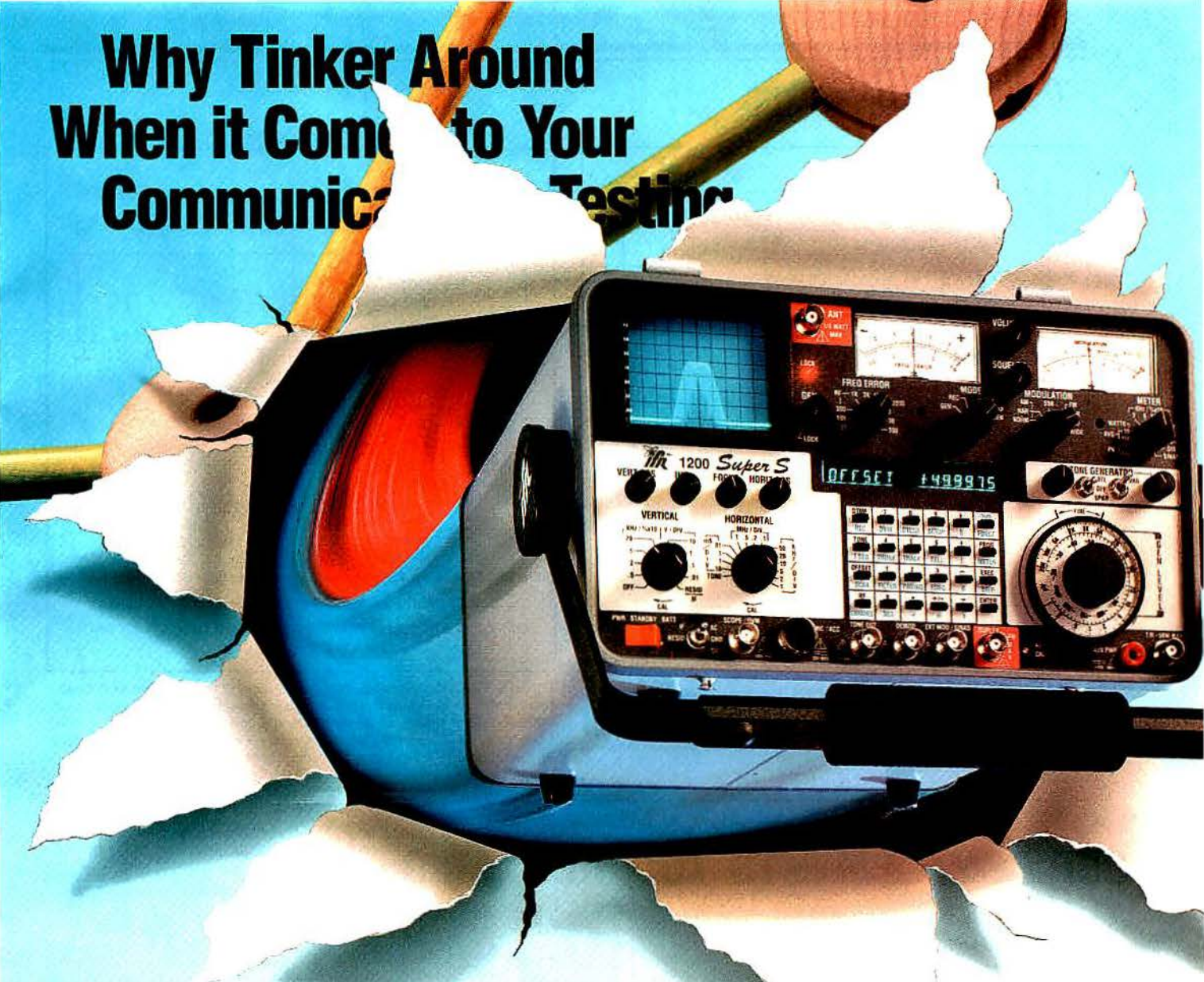

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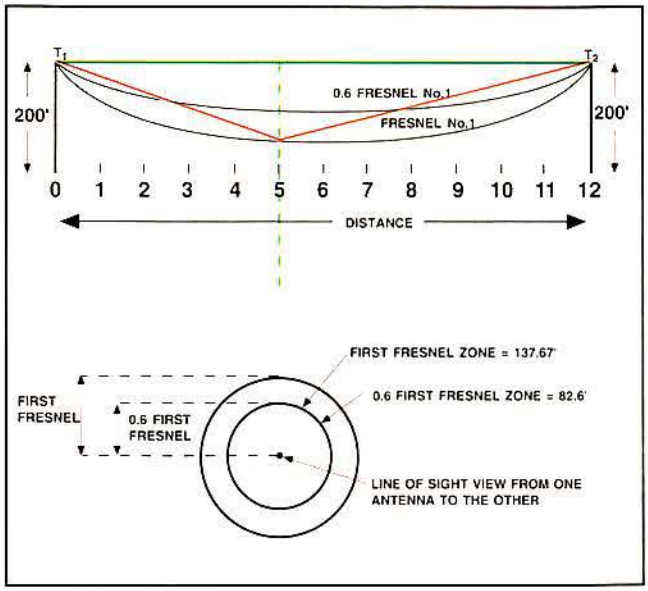

Figure 3. Towers T_1 and T_2 are separated by 12 miles. The curved lines represent the limits of the first Fresnel zone and 60% first Fresnel zone. The straight green line represents the direct path between the two antennas. The solid lines bounded by the first Fresnel zone represent the indirect path. The indirect path bounded by the first Fresnel zone is 0.5λ longer than the direct path. The first Fresnel zone completely surrounds the direct path as shown at the lower part of the figure. The actual shape of the Fresnel zone would resemble an elongated football surrounding the line-of-sight path.

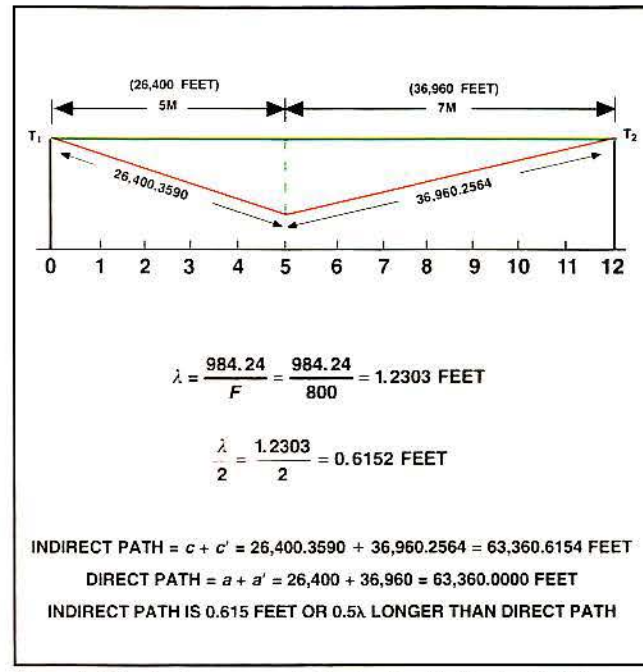

Figure 4. This drawing represents the direct and indirect path of the same towers shown in Figure 3. Line *b*, extending down from the direct path, represents the radius of the first Fresnel zone at a distance of 5 miles from tower T_1. The direct path is equal to $a + a'$. The indirect path is equal to $c + c'$, and is 0.5λ longer than the direct path.

Formula 2 in the sidebar can be rearranged to find the required height of the second tower if the required radio line-of-sight distance D and the height of the first tower (h_1) are known. It is rearranged as follows:

$$h_2 = \frac{(D - \sqrt{2h_1})^2}{2}$$

Remember, these calculations are for radio line-of-sight over smooth earth. Unfortunately, the earth is not very smooth in many places. The profile of the earth's terrain must be taken into account when establishing radio line-of-sight communication between two fixed points.

One way of constructing a path profile is to use a topographic map to compute the various elevations between the two fixed points and then plot them on $^4/_3$ earth curvature profile paper. (See Figure 2 on page 8.) Here, using the lowest scales, the height of tower A is 100 feet, and the height of tower B is 200 feet. The terrain profile (compiled from topographic maps) has been sketched in. Although there is a hill about 7.4 miles from tower A, there is a clear line-of-sight path between towers A and B.

Free-space attenuation

To achieve free-space attenuation (or

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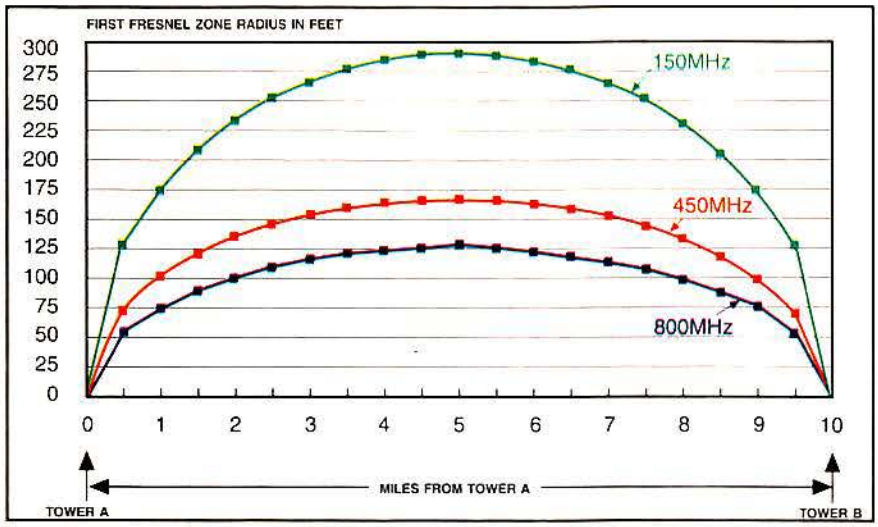

Figure 5. This graph shows the radius of the first Fresnel zone at three frequencies at any point between two towers separated by 10 miles. Notice how much smaller the first Fresnel zone radius is at 800MHz compared to 150MHz.

something close to it), an extra margin of clearance (more than radio line-of-sight) must be provided. For example, in Figure 2, even though radio line-of-sight exists between towers A and B, free-space attenuation is not achieved because of *diffraction* loss caused by the hill at distance D_1 from tower A. To achieve almost free-space attenuation between towers A and B, at least 60% of the first Fresnel zone must clear the obstruction (hill).

Fresnel zone

The Fresnel zone is best described by example. Figure 3 on page 58 shows the first Fresnel zone and 0.6 first Fresnel zone for a line-of-sight path between two antennas separated by 12 miles at a frequency of 800MHz. In practice, it is desirable to have at least 0.6 first Fresnel zone clearance to achieve almost free-space attenuation between two antennas.

In Figure 3, the first Fresnel zone radius extends 137.67 feet outward from the line-of-sight path at the five-mile point. This zone would completely encircle the line-of-sight path as shown at the bottom of Figure 3. The maximum extension of the first Fresnel zone radius would occur at the midpoint in the transmission path (at the six-mile point in the example in Figure 3). The direct path is indicated by the straight dashed line between towers T_1 and T_2. The indirect path is indicated by the two solid lines that meet at the first Fresnel zone radius. For the first Fresnel zone, the indirect path is one-half wavelength ($\lambda/2$) longer than the direct path. This is shown more clearly in Figure 4 on page 58.

Referring to Figure 4, line b is the radius of the first Fresnel zone. The indirect path ($c + c'$) is 63,360.6154 feet. The direct path ($a + a'$) is 63,360.0000 feet. Thus, the indirect path is 0.6154 feet longer than the direct path. This distance (0.6154 feet) is equal to $\lambda/2$ at 800MHz.

At any point between the two towers (T_1 and T_2), where b is the radius of the first Fresnel zone, the indirect path ($c + c'$) will always be $\lambda/2$ longer then the direct path ($a + a'$). Distances c and c' are found from the Pythagorean theorem:

$$c = \sqrt{a^2 + b^2}$$

Frequency versus Fresnel zone

As the frequency increases, the radius of the first Fresnel zone becomes smaller, thus drawing closer to the direct line-of-sight path and requiring less clearance between the direct line-of-sight path and any obstruction. This reduction is illustrated by Figure 5 above, which shows the radius of the first Fresnel zone at three frequencies (150MHz, 450MHz and 800MHz) between two antennas 10 miles apart. Notice the difference between the first Fresnel zone radius at 150MHz and 800MHz.

Computerized terrain profiles

As mentioned earlier, profile paper with $^4/_3$ earth curvature can be used to plot terrain profiles on a particular radial or azimuth between two fixed points. Even so, this requires careful interpretation of topographic maps, and many points must be plotted on the profile paper to give sufficient resolution of the profile. This can

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take up a lot of valuable time.

The alternative is to use a software package that includes terrain profile data (elevations). The software can generate a complete terrain profile graph in a short time while you take care of other business.

Figure 6 on page 64 shows a computer-generated profile path with a 0.6 first Fresnel zone radius added. The dashed lines in the figure were not generated by the program, but have been added to show that 60% of the first Fresnel zone radius at a distance of 3.5 miles (from the antenna on the left) is 151.75 feet. This figure is the same as what would result from applying Formula 5 in the equations sidebar and then multiplying the result by 0.6 to get 60% of the first Fresnel zone.

Figure 6 shows that the antenna elevations do not offer clearance of 60% first Fresnel zone between them. Therefore, the path loss will be greater than free-space path loss. If clearance of 60% first Fresnel zone is desirable, the antenna height can be increased. This change is shown in Figure 7 on page 64 where the antenna height is 1,000 feet above mean-sea-level as compared to 910 feet in Figure 6. The result is a good clearance of 60% first Fresnel zone, which will result in minimal diffraction loss from the obstruction and which will yield almost free-space path loss between the two points.

If the operating frequency were 800MHz instead of 160MHz, the clearance would be 60% first Fresnel zone without raising the antenna height. (See Figure 8 on page 64.) Notice that 60% first Fresnel zone in Figure 8 is much smaller in radius than for the 160MHz 60% first Fresnel zone shown in Figure 6.

Figure 9 on page 64 shows a 50-mile path with the $^4/_3$ earth curvature drawn by computer. Note the considerable mid-earth bulge at the midway point on the path. Even if the terrain were extremely smooth, considerable antenna heights would be required to overcome the mid-earth bulge.

Even when line-of-sight paths are established with proper Fresnel zone clearance, problems can occur that yield results much worse than free-space propagation conditions.

Even when line-of-sight paths are established with proper Fresnel zone clearance, problems can occur that yield results much worse than free-space propagation conditions. Figure 10 on page 66 depicts a situation described to me by George Weimer of Trott Communications Group, Irving, TX. In the San Francisco area, under normal weather conditions a good, clear, line-of-sight path exists between the antennas in the example. During a temperature inversion, a thick fog layer forms and reflects radio waves (as shown by the dashed lines), resulting in a significant increase in the path loss between the two antennas.

The solution is to allow enough *fade margin* in the design to cover such anomalies. Too much built-in fade margin drives up the cost, whereas too little may severely reduce the path reliability, causing

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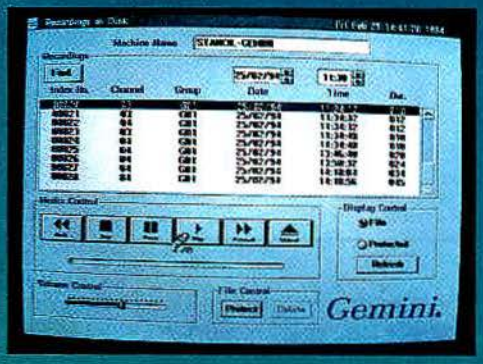

DAR - Gemini provides archival recording linked to DAT (Digital Audio Tape), currently the most cost effective high capacity digital storage format, saving 24 hours of conversation on each recording channel. A mouse driven GUI (Graphic User Interface) allows for simple location of stored conversations and total control of playback. Click on the selected channel,

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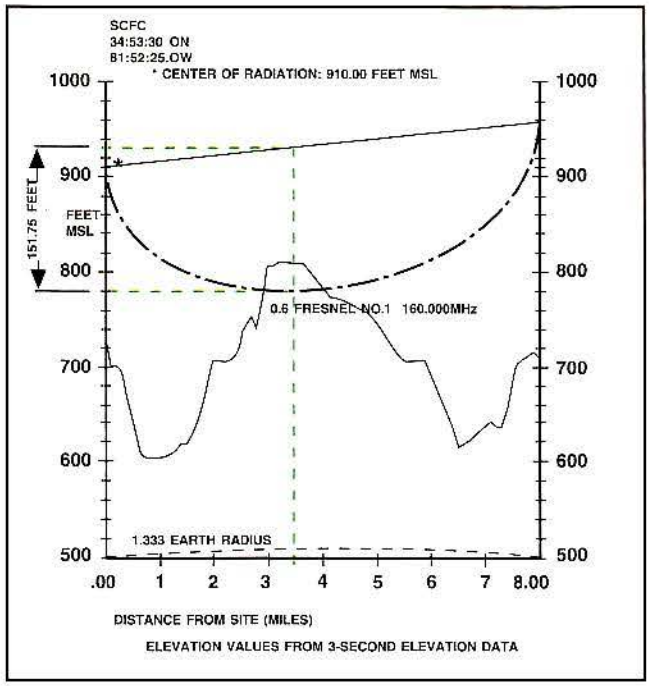

Figure 6. This terrain profile graph shows that a line-of-sight path exists between the tower on left and tower on right. Even so, at 160MHz, the path does not include 60% clearance of the first Fresnel zone. This graph was plotted with SoftWright's terrain analysis package (TAP) software.)

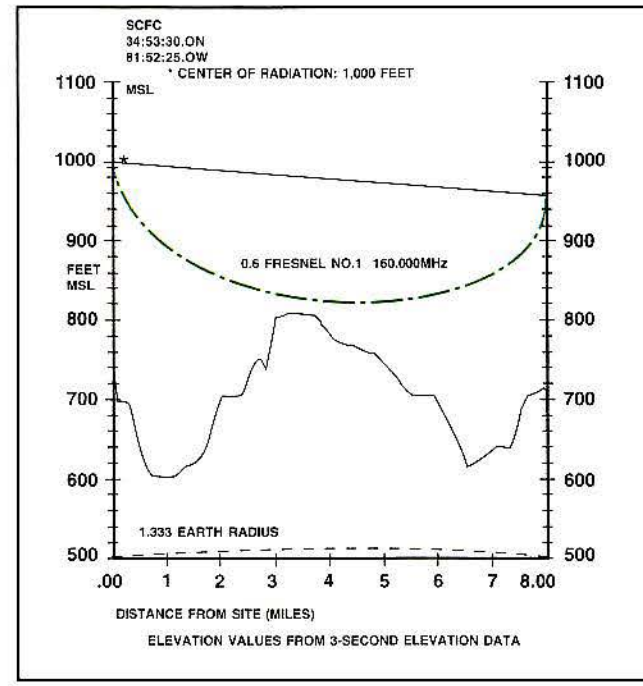

Figure 7. The tower on the left has been raised by 90 feet (compared to the same tower in Figure 6) to achieve more than 60% first Fresnel zone clearance over the obstruction 3.5 miles away. This graph was plotted with TAP software.

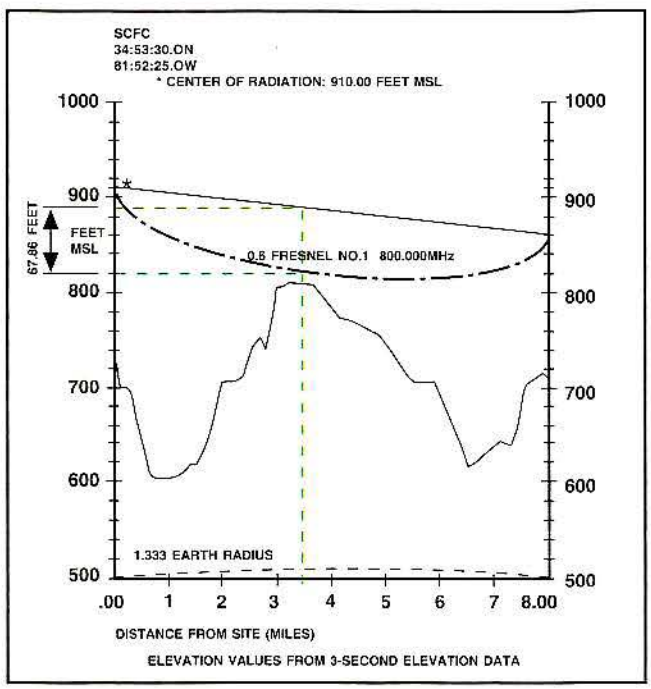

Figure 8. This terrain profile graph compares an 800MHz Fresnel zone and a 160MHz Fresnel zone. Note from Figure 7 that the left tower had to be 1,000 feet above mean sea level to achieve 60% first Fresnel zone clearance. Here, at 800MHz, 60% first Fresnel zone clearance is achieved with a tower height of 910 feet above mean sea level. The drawback is that the free-space path loss at 800MHz is about 14dB greater than the free-space path loss at 160MHz. This graph was plotted with TAP software.

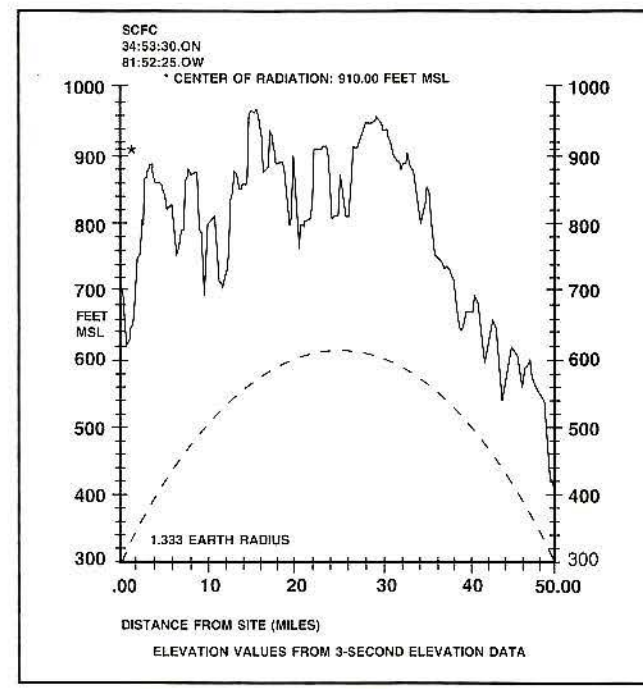

Figure 9: This terrain profile graph shows the tremendous effect of the earth's curvature over longer path distances. Tower heights greater than 300 feet would be required at each end of the path merely to clear the 'smooth earth's' curvature. Add to that the actual terrain profile, and the required tower heights for a line-of-sight path would be approximately 980 feet – 300 feet = 680 feet on each side. To achieve 60% first Fresnel zone clearance would require substantially greater tower heights. This graph was plotted with TAP software.

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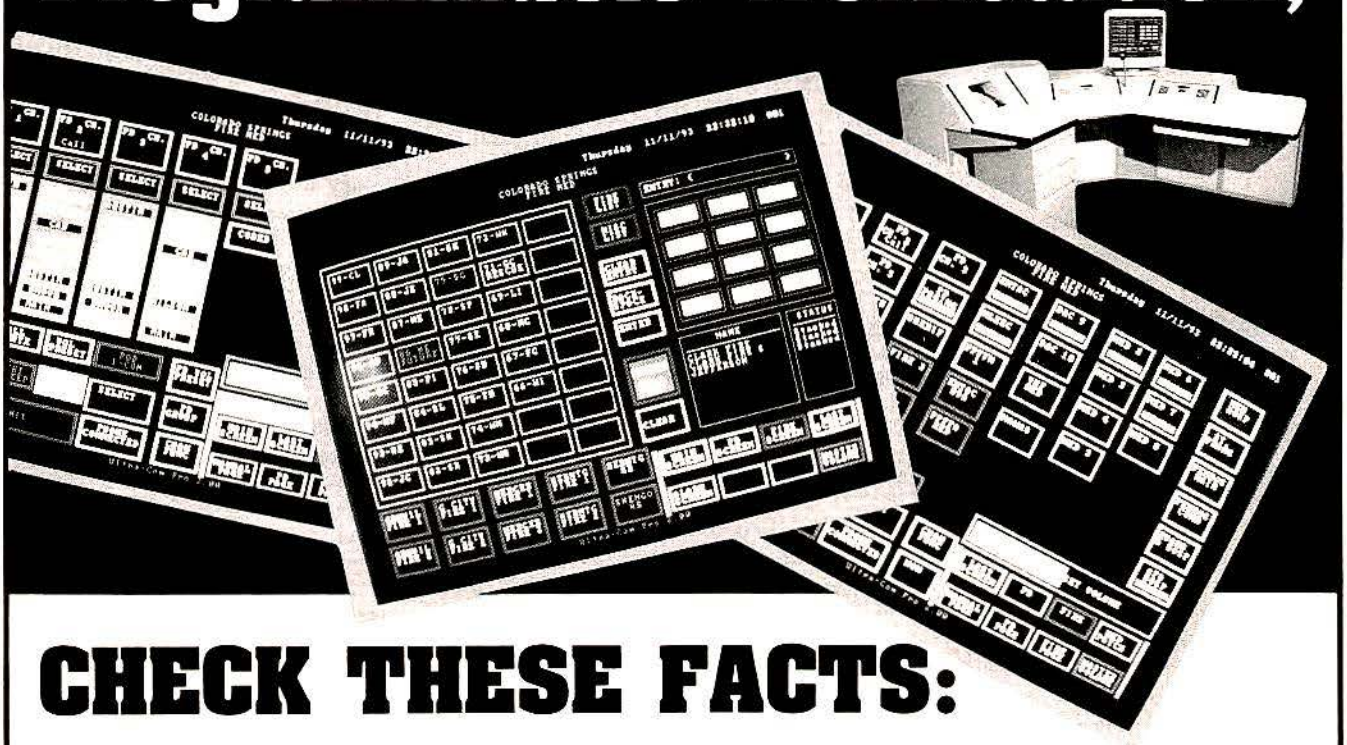

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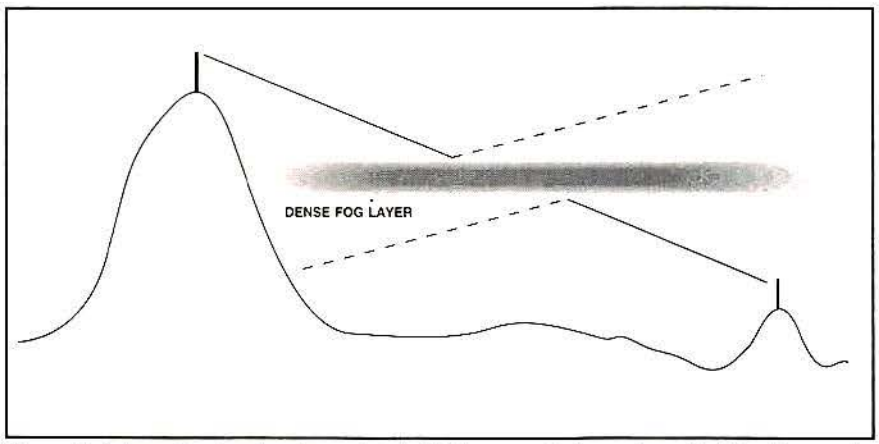

Figure 10. A dense fog layer has formed at a height between the two antenna heights. As a result, the signal from the higher antenna is reflected from the top of the layer, and the signal from the lower antenna is reflected from the bottom of the layer, resulting in significant attenuation to the path.

temporary interruptions in communications. Fade margins of 25dB to 30dB are often adequate, but there are special circumstances (such as this fog example) where a much higher fade margin might be required if the communications path is to be highly reliable. Use a common-sense approach along with your technical knowledge and data to find the "happy medium" level between overdesign and underdesign.

For those who would like computer programs that compute radio-horizon, first Fresnel zone and free-space path loss, I just happen to have some available! These programs compute the radio line-of-sight distance between two towers of specified height (smooth earth) or between a single tower of specified height and the horizon. The Fresnel programs compute the first Fresnel zone and 60% first Fresnel zone using meters, kilometers, feet, miles, wavelength and frequency. You can choose the measurement units from the menu. The free-space path loss program computes free-space path loss between two halfwave dipole antennas. Two additional programs are included to make conversions between wavelength (meters and feet) and frequency in megahertz as well as conversions between kilometers, miles, meters and feet—five programs in all.

These programs are for IBM-compatible computers running MS-DOS and are available on a single floppy diskette. Write to the author at 204 Tanglewylde Drive, Spartanburg, SC 29301-2949. Specify 5¼" or 3½" floppy. The cost is $10 for either size diskette plus $2.50 for shipping and handling.

Special thanks to Mike Wiebe of SoftWright for providing assistance with the terrain analysis profiles and to George Weimer of Trott Communications Group for answering specific questions. *Stay tuned!*

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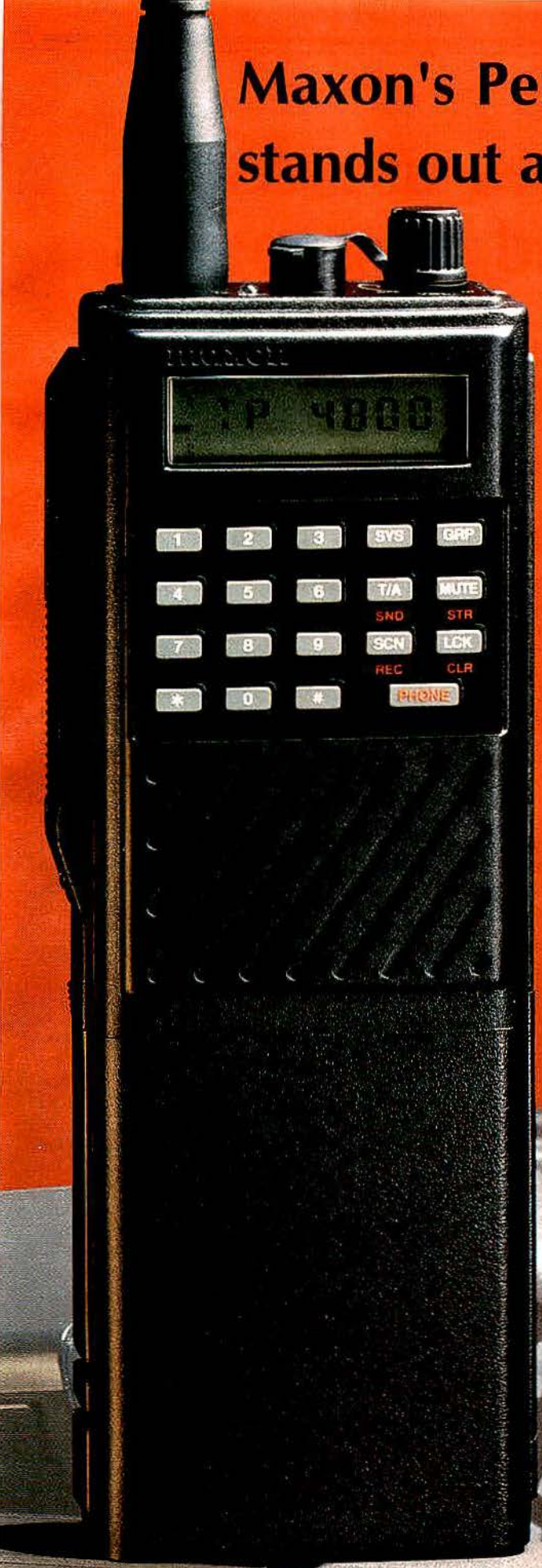

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Transit services use AVL to help disabled passengers

From record-keeping to visual and aural announcements of stops and route information, automatic vehicle location helps city bus services to comply with the Americans With Disabilities Act.

By Larry Watkins

More than 45 million Americans have one or more physical or mental disability, and with the rapid population growth, this number is increasing. Historically, society has tended to segregate individuals with disabilities in such critical areas as transportation. Today, cities are making public transportation more accessible to disabled citizens by complying with the Americans with Disabilities Act (ADA).

Watkins is senior principal engineer at Harris Corporation's Electronic Systems Division in Melbourne, FL.

In January 1990, Congress passed the ADA as a comprehensive national mandate to eliminate discrimination against individuals with disabilities. One provision requires transit authorities to provide a broad range of special services for the disabled. In October 1991, a law was passed requiring city buses on fixed route systems to adequately serve the sight- and hearing-impaired by announcing and prominently displaying within the bus indications for the next-stop and for major intersections. Route and destination information also must be announced and displayed externally as the bus arrives at each bus stop.

Although bus drivers can make sign changes and call out each stop via a loudspeaker or a voice annunciator, the notification does not always work. Drivers can become preoccupied and forget to announce stops. Despite efforts to comply with the ADA, lack of service and mistakes can often lead to lawsuits and federal funding problems.

Automatic vehicle location (AVL) systems solve the ADA requirements and deliver correct announcements at the right locations, on time, every time, relieving unreasonable pressure on the driver. With voice playback and display subsystems on board, the vehicle logic unit (VLU), which incorporates a Global Positioning System (GPS) receiver, triggers announcements and displays based on location data from the GPS receiver. With the success of GPS, vehicle location has now become a viable element in modern transit communications systems and a valuable tool in ADA compliance.

Harris is providing an advanced communications system for Metro-Dade County, FL, that uses GPS technology to link emergency and transit employees and to track county vehicles.

Transit communications

The standard transit communication system infrastructure includes a multisite radio system supported by a digital microwave backbone network. (See Figure 1 on page 70.) Transit radio systems are licensed in the 450MHz band, although the use of trunked 800MHz frequencies is increasing. Larger systems incorporate simulcast transmitters and voted receivers; smaller systems use one transmitter site. Whether to use simulcast, multisite control or single-site designs is dictated by the unique system coverage and operational requirements of each transit authority.

For data communications, full-featured transit systems use one or more dedicated radio channels, depending on the number of vehicles in the fleet and the frequency of reporting that is required.

In some systems, data transmissions take place on an exception basis, using a controlled-contention protocol, whereas other systems use periodic vehicle polling or time-synchronized vehicle reporting.

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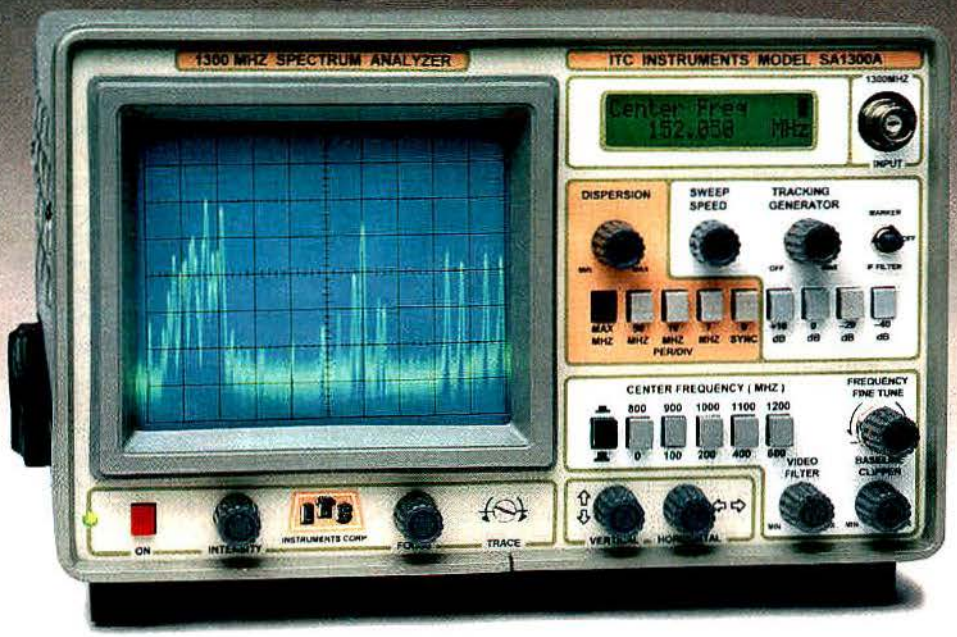

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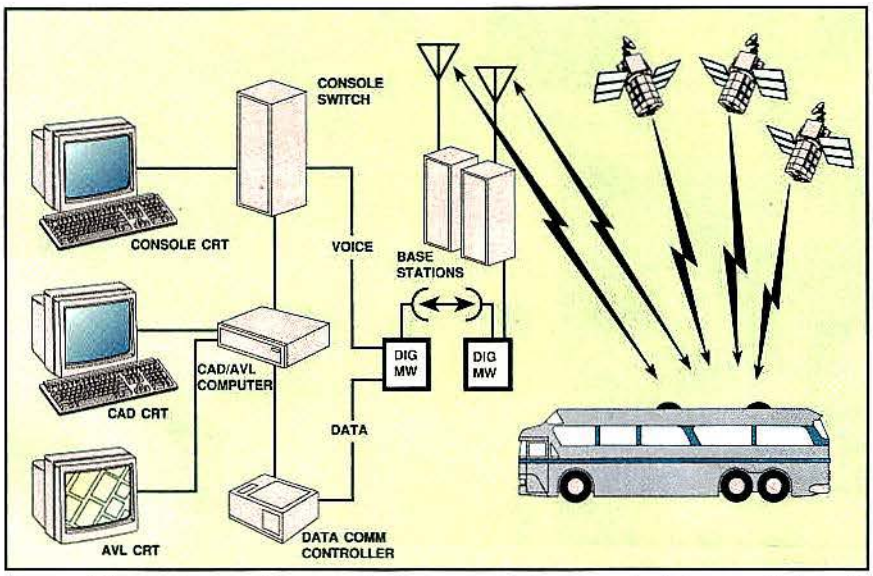

Figure 1. The standard transit communication system infrastructure includes a multisite radio system supported by a digital microwave backbone network.

Periodic reporting of vehicle location is necessary if near real-time tracking of vehicles and schedule adherence is required.

At the fixed end, data channel control and radio modems typically reside in a data communications controller (DCC) as shown in Figure 1. The DCC handles real-time information and commands to and from the computer-aided dispatch (CAD)/AVL terminals and associated databases.

Aboard the bus, data communications control resides in a vehicle logic unit. (See Figure 2 on page 72.) The VLU manages interfaces with the transit control head and onboard subsystems, including the internal GPS receiver. In most existing systems, interconnection between the VLU and peripheral devices uses a combination of RS-232C and vendor proprietary interfaces. Most new systems will use the SAE J1708 data bus for on-vehicle communications.

Unlike other radio services, access to voice channels in transit systems is tightly managed from the dispatch center through a *request to talk* (RTT) and *channel grant* protocol. When the driver pushes a request-to-talk button on the transit control head, the VLU formats and transmits the request via the data channel. Each data transmission also includes the bus identification number, the route-run-block number, the driver ID number, a vehicle location update and other data as applicable.

At the fixed end, the DCC delivers the request to the computer-aided dispatch processor, which then displays the RTT in a special field on the dispatcher CAD screen. The dispatcher responds via the

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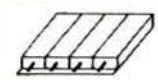

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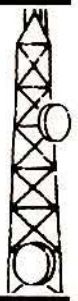

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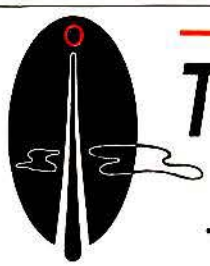

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Hutton Communications	34	28	800-442-3811
Hy-Q International	95	100	606-283-5000
ICT Systems, Inc.	85	79	800-779-1917
IFR Systems, Inc.	57	53	316-522-4981
Interactive Systems, Inc.	82	82	703-812-8270
ITC Instruments	69	65	800-566-1818
JPS Communications	46	40	919-790-1011
Kenwood U.S.A. Corporation	59	55	310-639-4200
Larsen Electronics	15	12	800-426-1656
Lazer Beepers, Inc.	108	139	800-354-3405
Lett Electronics Co.	100	116	800-521-2468
Maxon America, Inc.	67	64	816-891-6320
McManus Communications	95	102	501-763-6250
Mechem Electronics	103	128	703-373-3888
Megahertz Technology, Inc.	100	118	214-341-0562
Meridian Communications	31	25	818-888-7000
Microwave Filter Company, Inc.	20	16	315-437-3953
Midian Electronics, Inc.	49	44	602-884-7981
Midland International LMR	41	35	800-MID-LAND
Mobile Mark, Inc.	56	52	800-648-2800
Modular Communications Sys.	65	61	818-764-1333
Moss Communications	96	104	813-258-8777
Motorola	106	134	800-325-4036
Motorola C & E	110	144	708-538-6333
Motorola GPID	11	9	708-538-3000
Motorola Test Equipment	17	14	800-235-9590
Multiplier Industries Corp.	38	32	800-642-2424
MX-COM, Inc.	7	7	800-638-5577
NATCOM, Inc.	95	99	800-844-8287
Norton Engineering	105	133	703-938-5745
Omnicron Electronics	66	62	203-928-0377
Orbacom Systems, Inc.	27	22	609-829-4455
Palomar Telecomm, Inc.	99	115	619-746-7998
PanaVise Products, Inc.	30	24	702-353-2900
Pekaar Communication, Inc.	103	129	201-772-0704
Percon Corporation	109	142	716-386-6015
Photocomm, Inc.	70	66	800-223-9580
Pipo Communications	101	121	916-644-5444
Pirod, Inc.	66	63	219-936-4221
Polaris Industries	99	111	800-752-3571
Polyphaser Corp.	86	72	800-325-7170
Pyramid Communications	97		310-430-5892
Rabun Labs	99	112	800-788-1824
Radio Central	103	130	205-438-4465
Radio Express, Inc.	104	132	703-266-1928
Radio Wholesale	98	110	800-53R-ADIO
RAM Communications Consult.	92	95	908-636-6970
Ramsey Electronics	101	120	716-924-4560
RCW Distributing	102	123	800-726-9015
Relm Communications	IBC,90	2,87	317-545-4281
Santa Fe Distributing	78	75	913-492-8288
Schlumberger Technologies	37	31	800-225-5765
Scientific Dimensions, Inc.	99	113	505-345-8674
Setcom Corp.	58	54	415-965-8020
Sharp Communication	102	124	800-548-2484
SMC Electro-Mount	60	56	800-527-1079
Softwright	107	138	303-344-5486
Solar Electric Specialties	80	79	800-344-2003
Sonic Communications, Inc.	22	18	800-688-1944
Stancil Corporation	63	60	714-546-2002
Sti-Co Industries, Inc.	42	36	716-662-2680
Survey Technology	44	38	503-591-5986
S. W. & Associates	76	89	313-559-3237
Tait Electronics USA, Inc.	24	20	713-984-8684
Telemessaging Devices, Inc.	79	77	800-645-4595
Telewave, Inc.	74	71	415-968-4400
TGA Systems, Inc.	36	30	404-441-2100
Times Microwave Systems	21	17	203-949-8400
Towerwatch	111	145	913-233-2343
Transcrypt International Ltd	3	5	800-228-0226
Transtronics, Inc.	82	81	913-841-3089
Trident Micro Systems	70	67	800-798-7881
Trimble Navigation	61	57	800-545-6606
Trylon Manufacturing Co., Ltd.	90	86	519-669-5421
TX RX Systems, Inc.	39	33	716-549-4700
Vega, A Mark IV Company	1	4	818-442-0782
Versatel Communications	98	109	800-456-5548
Vocom/RF Corporation	62	58	800-USA-MADE
Wacom Products, Inc.	16	13	817-848-4435
Western Multiplex Corp.	71	68	415-592-8832
Wetec Electronics	101	122	901-268-6275
Wireless World Conference	75		913-967-1848
W & W Associates	47	41	800-221-0732
Zetron, Inc.	43,81,89	37,80,85	206-820-6363

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